Essays on Financial Development, Inequality and Economic Growth

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Abstract

This thesis explores two important aspects of growth, namely the roles of financial development and inequality. The recent literature has indicated that both the finance-growth and inequality-growth relationships are complex and not well captured through conventional linear regression analyses. Thus, most of the existing empirical literature focuses on marginal or direct growth effects, ignoring the role of possible factors, conditions and thresholds that may alter our thinking about how financial development or inequality may affect economic growth. Further, it ignores the presence of outliers, especially in cross-sectional analyses which may hinder our understanding of these relationships. Therefore, Chapter 1 addresses the issue of outliers in finance-growth literature and provides a robust sensitivity analysis of some past studies and an updated data set. Chapter 2 focuses on whether R&D plays a role, potentially as a proxy for an omitted variable, for growth and whether it has important interactions with financial development. Chapter 3 then examines the role of inequality for growth, allowing the effects to differ depending on the level of human versus physical capital accumulation.

The cross-sectional analysis of Chapter 1 employs the robust regression methods of median quantile regression and least trimmed squares. It shows that the findings of past studies are sensitive to outlier observations. Further, we find that the positive effect of financial development on growth disappears and even becomes negative once we use our extended data set of 86 countries over the period 1997-2006. This last finding is consistent with Rousseau and Wachtel (2011). Moreover, we investigate whether our understanding of the finance-growth relationship can further be improved by introducing a measure of R&D into the standard analysis. We note that our measure of R&D has a strong positive effect on growth and may proxy the role of an omitted variable which is highly correlated with economic growth.

Chapter 2 also uses R&D and investigates its interaction with conventionally measured financial development. It employs a variety of panel data techniques for a panel of 36 OECD and non-OECD countries to show that the relationship between financial development and economic growth is not straightforward; rather, it is conditional upon the level of innovation or R&D. Further, we find that a high level of technological innovation or R&D is associated with a weak or negative effect of financial development on economic growth. It is also noted that R&D is associated with financial innovation and the results suggest that countries with a high level of R&D may have less regulated financial systems which can adversely affect the finance-growth relationship.

The third chapter explores the relationship between inequality and growth in the context of a unified empirical approach suggested by the theoretical model of Galor and Moav (2004). Based on that model, we construct a new measure, the human capital to physical capital ratio, which is used to study threshold effects in the inequality-growth relationship. Methodologically, we use threshold regression with instruments, developed by Caner and Hansen (2004), which allows us to endogenously identify the threshold human capital to physical capital ratio that alters the inequality-growth relationship. Using data on 82 countries, our results show that there exist significant threshold effects, with a level of the human capital to physical capital ratio below which the effect of inequality on growth is positive and significant, whereas it is negative and significant above it. We also test the robustness of our results using different measures of the human capital to physical capital ratio. These results are consistent with the theoretical predictions of Galor and Moav (2004).

Declaration

that no portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning

Copyright Statement

Dedication

To

The most respected and honourable

Prophet Muhammad (*peace and blessings be upon him*)

My Father, Ali Muhammad Bhatti

Mother, Rasheeda Bibi (*Late*)

& Brother, Karamat Ali Bhatti

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I begin with the blessed name of Allah (AJ) who gave me the ability and strength to complete my PhD. I praise Him and glorify Him as He ought to be praised and glorified. I pray for peace and blessings on all His noble messengers, especially on the last Prophet Muhammad (PBUH) who is created as a blessing for mankind as well as all the universes. I am not fit to speak of his exalted glory with narrow perceptions and low imagination.

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The Author

Arshad Ali Bhatti S/O Ali Muhammad Bhatti was born in Lahore, Pakistan. He completed his early education from Imtiaz Public High School Lahore and undergraduate degree (with mathematics, physics and statistics) from Government F.C. College Lahore. He studied economics at International Institute of Islamic Economics (IIIE), International Islamic University Islamabad and got MSc and MPhil degrees. Later on, he was appointed as a lecturer in economics at IIIE in 2002, and was selected as Assistant Professor in 2008. He has been awarded a PhD scholarship by Higher Education Commission of Pakistan (HEC) in September, 2007 that he won through a nationwide competition for pursuing PhD in Economics at The University of Manchester, UK. He is married to Fatima Bhatti and has two lovely children, Hamza and Rumaysa.

Thesis Introduction

Since Adam Smith (1776), it has become a norm in growth literature to discuss 'Why some countries are rich while the others are poor?' However, despite more than two hundred years economists are unable to resolve this issue. Countries at the top of the world income distribution are more than thirty times richer than those at the bottom. Evidence shows that this gap can be attributed to real per capita growth which in turn depends on investment in physical capital, human capital, and technology. However, these proximate causes alone cannot explain satisfactorily the process of economic growth without looking into the reasons for differences in physical capital, human capital, and technology across countries. Hence, the answer to the above question may be related to fundamental causes of growth like luck, geographic differences, institutional differences, and cultural differences etc. (see Helpman, 2004, Ch-1; Acemoglu, 2008, Ch-1).

Recent growth analyses focus on a range of factors that may help to explain the nature of the growth process across countries. For example, the development of financial institutions and markets is found to be a key element in the efficient allocation of resources and the productivity of firms (see Levine, 1997; Ang, 2008; Acemoglu, 2008, Ch-21). Similarly, income distribution may play an important role in defining the growth path of countries (see Galore, 2000; Galore and Moav, 2004; Acemoglu, 2008, Ch-21). There are also numerous theoretical and empirical studies that attempt to investigate the nature of these relationships, and hence try to answer the fundamental question of why some countries are rich while the others are poor. Yet, there is need to explore in detail the precise factors, conditions, and thresholds that may affect our understanding of these relationships.

The standard neoclassical theory implicitly assumes that financial systems function efficiently; hence most growth analyses include physical capital, human capital, and technological innovation as the proximate causes of growth. From the 1980s[1], many developing countries have relied on the private sector and market signals to direct the allocation of resources, which in turn requires efficient financial institutions and markets. Well functioning financial systems provide opportunities for all market participants to channel funds to their most productive uses that may

[1] See details in World Bank, 1989.

enhance economic growth, thus improving income distributions and reducing poverty (see Levine, 1997; World Bank, 1989; Demirgüç-Kunt et al, 2008; Ang, 2008).

A strand of literature incorporating financial institutions in endogenous growth analyses emerges in the 1990s. The central argument of endogenous growth models is that finance generates an external effect on aggregate investment efficiency which offsets decreases in the marginal productivity of capital. Numerous past empirical studies show there is a positive and significant relationship between financial development and economic growth (see King and Levine, 1993; Levine, 1997). For example, King and Levine (1993a) is the most prominent study during the 1990s that started a continuous debate concerning the finance-growth relationship. Their cross-sectional analysis uses bank-based measures of financial development to show that there is strong positive association between financial development and economic growth.

Many later studies focus on either bank-based or market-based, or both, as measures of financial development by employing a broader range of measures and incorporating panel data. They conclude that the relationship between banks, stock markets, and economic growth is statistically robust. Overall, their results are consistent with the view which stresses the importance of financial services rather than its providers like banks or stock markets. They show that financial intermediaries and markets are complements rather than substitutes in promoting growth, while also emphasizing the need of in-depth time series analysis (see Levine and Zervos, 1996; Levine and Zervos, 1998; Rousseau and Wachtel, 2000; Beck et al, 2000b; Beck and Levine, 2002; Beck, 2003; Beck and Levine, 2004; Ndikumana, 2005; Ang, 2008). However, some studies find that the contribution of banks is more powerful as compared to stock markets, where the role of the latter may have been exaggerated by cross-sectional studies (see Arestis et al, 2001).

Cross-sectional analysis may face the problems of endogeneity and country specific effects, and thus is unable to address the issue of causality, whereas the time series literature focuses on the causal relationship between financial development and economic growth. The empirical findings of this latter strand of literature show mixed results and suggest that causality effects are country specific and cannot be generalized, thus, indicating the potential danger of combining different countries with different institutional characteristics and backgrounds (see Demetriades and

Hussein, 1996; Arestis and Demetriades, 1997; Hansson and Jonung, 1997; Asteriou and Price, 2000; Shan and Jianhong, 2006).

Being specific to cross-sectional analyses, most of the existing studies on the finance-growth relationship include some sensitivity analyses in order to check the robustness of their results: for example, various conditioning information sets, regional or income dummies, sub-samples of countries and time periods, different measures of financial development, outlier detection by simple scatter plots or ad hoc measures and various estimation procedures etc. (see King and Levine, 1993a; Levine and Zervos, 1998; Beck et al, 2000a; Beck and Levine, 2004; Rajan and Zingale, 1998; Manning, 2003; Chinn and Ito, 2006). The empirical evidence, however, shows that a small variation in the conditioning information set of growth regressions can alter the relationship between explanatory variables and growth, including the indicators of financial development (see Levine and Renelt, 1992). Further, most of the cross-sectional studies on growth and their sensitivity analyses use linear specifications (see Barro, 1991; Levine and Renelt, 1992; Beck and Levine, 2004; Rousseau and Wachtel, 2011); however, there are some exceptions who use non-linear sensitivity methods (see Kalaitzidakis et al, 2000).

Although a few studies in the growth literature employ the quantile regression approach to perform sensitivity analysis of growth regressions from the past literature (see Mello and Perreli, 2003), there is very little evidence of this type in the finance-growth literature. Robust regression methods are potentially extremely important in cross country analysis because the latter may contain a heterogeneous group of countries where the presence of outlier observations is very likely. It may be because countries may differ in the quantity and quality of financial services, degree of financial liberalization, financial regulations, enforcement of law and governance etc. The robust methods, contrary to ordinary least squares (OLS), produce regression estimates which are not sensitive to the presence of outlier observations in the data.

Very recently, literature on finance-growth analysis changes our thinking and brings into account the effects of financial innovation, excess finance and financial crises following the financial liberalization policies of the 1990s. It shows that excessive finance, which may be the result of technical change or financial innovation, is an amplifying factor behind the financial crisis which in turn adversely affects the finance-growth relationship (see Michalopoulos et al, 2010; Arcand et al, 2011; Ductor and Grechyna, 2011; Rousseau and Wachtel, 2011). Furthermore, this literature suggests that on the one hand technological innovation is important for economic growth, while on the other hand it has a strong positive relationship with financial innovation (see Michalopoulos et al, 2010). In this context, technological innovation may proxy the role of other variables. In particular, if countries with a high level of technological innovation also have more deregulated financial systems, then the apparent role of technological innovation will be quite complex. As evident from the recent financial crisis, unregulated or unmonitored financial innovation may result in excess finance which is very likely to cause financial crisis thus leaving an adverse effect on economic growth.

Contrary to the role of well functioning financial institutions and markets, less developed financial systems or credit market imperfections may promote inequality among the members of the society by allocating resources towards those with high marginal propensity to save. This important aspect of credit market imperfection has been recognized by the current theoretical and empirical literature on inequality-growth relationship through its effects on human capital formation (see Galore and Ziera, 1993; Demirgüç-Kunt et al, 2008 Ch-3; Demirgüç-Kunt and Levine, 2009). Further, Greenwood and Jovanovic (1990) is perhaps the pioneer theoretical work that combines the two important strands of literature on growth: finance-growth and inequality-growth. They predict a non-linear relationship between financial development, income inequality and economic growth. Their model implies that the relationship between growth and income distribution depends on financial development. At the early stage of economic development, the financial institutions and markets are less developed and the benefit goes to rich people. Consequently, there is rapid growth and the inequality across the rich and poor increases. In the latter stage of development, as the financial intermediaries expand and many people join them, income inequality decreases and economic growth increases at a faster rate than the early stage of development.

However, the earlier debate on the inequality-growth relationship focuses around the seminal work of Kuznets (1955) who argues that the distribution of income is mostly determined by the level of economic development. He shows that there exists an inverted U-shaped relationship between inequality and growth, where at the initial stage of development inequality increases growth while it reduces growth in the later stage of development (see Ehrhart, 2009).

The literature during the Seventies and Eighties is mostly based on cross-sectional analyses that largely confirms the Kuznets Hypothesis, results being sensitive to combining the data of developed and developing countries and functional forms (see Ahluwalia, 1976; Ram, 1988; Fields, 1981; Anand and Kanbur, 1993).

Following the empirical findings of the 1950s to early 1980s, theoretical models developed in the 1990s try to identify channels that may explain the nature of the relationship between income inequality and growth such as credit market imperfections, majority rule (political) and technological innovation etc. For example, Galor and Zeira (1993) is the seminal theoretical work which introduces the channel of credit market imperfection and shows that the initial distribution of income determines the level of aggregate investment in human capital and economic growth. Their analysis implies an 'inverse U-shape' relation between inequality and growth along the levels of income. A similar relationship is observed using the channel of income distribution through political process, that is, the higher the inequality in the distribution of income and wealth, the higher the tax rate and lower the rate of economic growth (see Alesina and Rodrik, 1994; Persson and Tabellini, 1994).

Despite sound theoretical foundations and relatively good quality data on income inequality, recent empirical literature draws mixed conclusions regarding the relationship between inequality and economic growth. On the one hand it finds a positive effect of inequality on growth which is partially consistent with the above theoretical predictions. These studies criticize the previous literature on the basis of using weak proxies of inequality, data quality, and estimation methodology while stressing more careful examination of inequality-growth relationship and the channels through which it is affected (see Partridge, 1997; Li and Zou, 1998; Forbes, 2000). On the other hand it finds that the effect of inequality on growth is negative, with this result is mainly driven by low income countries (see Panizza, 2002; Huang et al, 2009). Further, some empirical evidence shows that the effect of inequality on growth switches sign across the levels of income, profile of inequality, degree of urbanization, and/or time etc (see Deininger and Squire, 1998; Barro, 2000; Voitchovsky, 2005; Fallah and Partridge, 2007).

Much of the literature on this topic uses linear specifications, despite the nonlinearity between inequality and growth implied by the Kuznets hypothesis. Banerjee and Duflo (2003) criticize the results of Forbes (2000) and Li and Zou

(1998) and document that growth rate is an inverted U-shape function of net changes in inequality (in any direction) and that this relationship is robust to control variables and estimation methods. Their empirical findings are consistent with their simple theoretical model of political economy. Similarly, Chen (2003) finds that there exists an ‘inverted U-shape’ relationship between initial income distribution and long run economic growth. His results are consistent with the Kuznets Hypothesis with the only difference that the long run growth first increases and then decreases with the initial inequality.

Very recently, some theoretical studies, mainly led by Galor (2000) and Galor and Moav (2004), combine the previous two strands of literature in this field where the first documents a positive effect of inequality on growth while second favours the negative effect. The Galor studies show that in the presence of imperfect capital markets (credit constraints) human capital remains low as compared to physical capital and inequality channels resources to the owners of capital with high marginal propensity to save and thus increases growth. However, in the presence of well functioning financial institutions and markets credit constraints are no longer binding, which in turn facilitate the formation of human capital that may replace physical capital in promoting economic growth. With the single exception of Chambers and Krause (2010), no empirical study to date has explored the channel of human and physical capital as implied by Galor and Moav (2004) to study the relationship between inequality and growth.

The above discussion motivates us to explore two important aspects of growth analyses, namely financial development and inequality. In finance-growth analyses we explore the issue of outliers and the role of R&D for the effect of financial development on growth; in the context of inequality, the human capital to physical capital ratio is used as a threshold variable in the analysis of the inequality-growth relationship. This is an attempt to explore the precise factors, conditions and thresholds that may affect these relationships.

Thus, focusing on the above discussion this thesis is organized as follows. In Chapter 1, we examine the sensitivity of finance-growth regressions using some cross-sectional data sets from the past literature as well as our extended data set. Chapter 2 investigates the role of R&D for the effect of financial development on economic growth using a panel data set. In Chapter 3, we investigate whether the relationship between inequality and growth is affected by human capital to physical capital ratio as implied by Galor and Moav (2004).

In Chapter 1, we employ two robust methods of median quantile regression (QR) as suggested by Koenker and Bassett (1978) and least trimmed squares (LTS) as suggested by Rousseeuw and Leroy (1987) for the cross-sectional analysis of five data sets: the first four data sets are taken from Levine and Zervos (1998), Beck et al (2000a), Levine (2002), and Beck and Levine (2004); where the fifth data set is more up to date and extended across variables and countries. Besides using robust regression methods to perform sensitivity analysis of old empirical findings, we also analyse the specification of Beck and Levine (2004) using our extended data set by adding a measure of innovation or R&D, noting that this may proxy the role of an omitted variable which is highly correlated with economic growth.

In Chapter 2, we contribute to the finance-growth literature by using a measure of technological innovation or R&D that may show important interactive effect (with financial development) on growth. Hence, besides looking at the direct effects of financial development and R&D on growth, we address two important questions: whether the growth effect of financial development is conditional on the level of innovation or R&D; and whether a high level of technological innovation or R&D is associated with an apparently weak or negative effect of financial development on growth. We investigate these questions by employing a multiplicative interaction model, where the interactive effect of technological innovation and financial development on economic growth is analysed. We use a panel data of 36 countries (26 OECD and 10 non-OECD) over the period 1980-2006 to explore this conditional effect by employing a variety of panel data techniques.

Chapter 3 explores a different aspect of growth, namely the role of inequality in the context of a unified approach as suggested by Galor and Moav (2004). We construct a new measure of human capital to physical capital ratio (HK ratio) to study its threshold effects on inequality-growth relationship. For this, we use a pooled data of 82 countries for the period 1965-2003 and employ the method of threshold regression with instruments as suggested by Caner and Hansen (2004). This method can endogenously identify the threshold of human capital to physical capital ratio (HK ratio), treating HK ratio as exogenous variable. Further, we examine the robustness of our results by using different measures of human capital to physical capital ratio and the data sets.

Overall, the above three chapters contribute to the literature on finance-growth and inequality-growth relationships, by incorporating the important issues of robustness, interactive effects, and threshold effects that may affect these relationships.

Chapter 1

A Robust Sensitivity Analysis of Cross-Country Finance-Growth Regressions

1.1. Introduction

A financial system provides services that are essential in a modern economy such as mobilizing savings, allocating resources, exerting corporate control, facilitating risk management, and easing the trade of goods, services, and contracts (see Levine, 1997). The financial institutions and markets, by undertaking these functions, can affect economic growth through the channels of capital accumulation and total factor productivity (see King and Levine, 1993a, b; Levine, 1997; Ang, 2008). Channelling funds from surplus units to deficit units with more productive uses for them raises the income of both the savers and the borrowers. Without an efficient financial system, however, lending can be costly and risky. The financial system's contribution to economic growth thus lies in its ability to increase efficiency (see Levine, 1997).

A substantial volume of research has been devoted to verify and understand the existence of linkages between financial development and economic growth. Historically, one such linkage is evidenced by the strong positive correlation between long-run economic growth and the degree of financial intermediation, while another is demonstrated by the similar correlation between long-run growth and stock market activity (see King and Levine, 1993a; Levine, 1997; Levine and Zervos, 1996, 1998; Beck et al, 2000b; Beck and Levine, 2004; Ang, 2008). However, some studies show that the effect of banking sector development on growth is more powerful as compared to the effect of stock markets; and that the effect of the latter may have been exaggerated by the cross-country studies (see Arestis et al, 2001). Both of these relationships may be explained by the possible opportunities of channelling a larger fraction of savings into relatively more productive investments. In the case of financial intermediation, these opportunities may arise from a greater pooling of risks, a higher quality of information, a lower cost of monitoring and a lower cost of transactions. In the case of stock markets, they may reflect a wider diversification of portfolios and a re-direction of resources towards longer-run, less liquid, but higher-yielding projects.

Recent literature on finance-growth analysis changes our thinking and brings into account the effects of financial crises, following the financial liberalization policies of 1990s. It shows that the relationship between financial development and growth is adversely affected during different periods of financial crisis that may be the result of financial innovation and excess finance (see Rousseau and Wachtel, 2011; Arcand et al, 2011; Ductor and Grechyna, 2011). In this context, the different measures of financial development may contain measurement error and the effects of financial bubbles that are likely to result in unusual findings and this problem may remain in averaged cross-sectional data (see Chinn and Ito, 2006). These findings motivate this chapter to explore the issue of extreme observations or outliers in detail, in order to investigate the extent to which the strong positive correlation between financial development and growth found in these studies may be due to outliers.

Most of the existing cross-sectional studies on finance-growth relationship include some sensitivity analyses in order to check the robustness of their results: for example, various conditioning information sets, regional or income dummies, sub-samples of countries and time periods, different measures of financial development, outlier detection by simple scatter plots or ad hoc measures and various estimation procedures etc. (see King and Levine, 1993a; Levine and Zervos, 1998; Beck et al, 2000a; Beck and Levine, 2004; Rajan and Zingale, 1998; Manning, 2003; Chinn and Ito, 2006). The empirical evidence, however, shows that a small variation in the conditioning information set of growth regressions can alter the relationship between explanatory variables and growth, including the indicators of financial development (see Levine and Renelt, 1992). Further, most of the cross-sectional studies on growth and their sensitivity analyses use linear specifications (see Barro, 1991; Levine and Zervos, 1996, 1998; Beck et al, 2000a; Levine and Renelt, 1992). However, there are some studies that employ nonlinear methods for sensitivity analysis of growth regressions (see Kalaitzidakis et al, 2000).

Although there are some studies in the growth literature that employ the quantile regression approach to perform sensitivity analysis of growth regressions from the past literature (see Mello and Perreli, 2003); there is very little evidence of this type in the finance-growth literature. Robust regression methods are potentially extremely important in cross country analysis because the latter may contain a heterogeneous group of countries where the presence of outlier observations is very likely. It may be due to countries varying with respect to their financial structures, financial regulations, rule of law, and degree of financial liberalization etc. These methods, contrary to ordinary least squares (OLS), produce regression estimates which are robust to the presence of outlier observations in the data.

In this chapter, we employ two robust methods of median quantile regression (QR) as suggested by Koenker and Bassett (1978) and least trimmed squares (LTS) as suggested by Rousseeuw and Leroy (1987) for the cross-sectional analysis of five data sets: the first four data sets are taken from Levine and Zervos (1998), Beck et al (2000a), Levine (2002), and Beck and Levine (2004); where the fifth data set is more up to date and extended across variables and countries. Besides using robust regression methods to perform sensitivity analysis of old empirical findings, we also analyse the specification of Beck and Levine (2004) using our extended data set. Furthermore, we note that most of the studies on finance-growth analysis ignore a potentially important variable of innovation and R&D. Hence, we add a measure of innovation or R&D in the specification of Beck and Levine (2004) that may represent an omitted variable which is highly correlated with economic growth. A deeper analysis of R&D and its interactive effects with financial development is provided in chapter 2. We use R&D expenditures to GDP ratio as a proxy for innovation. However, measuring the contribution of R&D investment to economic growth remains a complex issue which is subject to data observability, availability, and quality[2].

This chapter is organised as follows. Section 1.2 reviews some important studies in the field. Section 1.3 outlines our empirical methodology. Section 1.4 discusses robustness of the first four data sets from previous cross-country regressions. Section 1.5 reports the estimation and results using our fifth data set

[2] Department of Finance and Revenue, Canada (1997).

which is updated and extended across countries and variables, as compared with the first four sets. Finally, Section 1.6 presents conclusions.

1.2. Literature Review

A new strand of literature emerged in the 1990s seeking evidence in favour of endogenous growth theory. The central argument of endogenous growth models is that finance generates an external effect on aggregate investment efficiency which offsets the decrease in the marginal productivity of capital. There are numerous empirical studies which investigate the nature of the relationship between financial development and economic growth and conjecture that there is a positive and significant relationship between them (King and Levine, 1993a; Levine and Zervos, 1996, 1998; Arestis et al, 2001; Beck et al, 2000b; Beck and Levine, 2004; Rousseau and Wachtel, 2011; Arcand, 2011). However, some studies show that the effect of banking sector development on growth is more profound as compared to stock market development; where the latter effect may have been overemphasized by studies that use cross-country data (see Arestis et al, 2001).

An important study in this context is by King and Levine (1993a). They investigate whether higher levels of financial development are significantly and robustly correlated with faster current and future rates of economic growth, physical capital accumulation, and improvement in economic efficiency. Their analysis is consistent with the Schumpeterian view of creative destruction, according to which innovation replaces the old methods of production with better procedures, commodities, and services. Further, well functioning banks spur innovation in technology and products by channelizing funds to their most productive use. King and Levine (1993a) introduce four measures both for the financial development and growth and use cross-sectional and pooled data of 80 countries for the period 1960-1989.

They conclude that each financial development indicator is positively and significantly correlated with each measure of growth and that initially rich countries tend to grow more slowly than initially poor countries after controlling for the initial level of investment in human capital. Their results also support the famous view of Schumpeter (1934) that financial sector development causes economic growth by increasing the rate of capital accumulation and by improving the efficiency with which it is used. They check the robustness of their results by altering the conditioning information set, using sub samples of countries and time periods and examining the statistical properties of the error terms.

Despite this strand of literature finding a positive and significant relationship between financial development and economic growth, the issue of causality remained unresolved. For example, Demetriades and Hussein (1996) focus on causality using time series data for 16 developing countries, with a population of more than one million in 1990. They find little support in favour of the finance-lead-growth hypothesis. Their results are mixed, most of the countries show bi-directional causality, while, some exhibit reverse causality. They conclude that the causality results are country specific and cannot be generalized, thus, indicating the potential danger of combining different countries with different institutional characteristics and backgrounds.

Some case studies, including Arestis and Demetriades (1997), focus on different financial structures to try to resolve the issue of causality and the impact of different financial policies on economic growth. They examine whether, how, and to what extent the financial system can contribute to economic growth and whether financial liberalization can stimulate investment and economic growth. They provide a time series analysis for Germany and the United States using quarterly data for the period 1979 to 1991. They conclude that in Germany there is uni-directional causality from financial development to real GDP and that stock market capitalization affects real GDP only through the banking sector, while stock market volatility has a negative effect on output. In the case of USA the results are not clear, which may be, mainly, due to the endogeneity of stock market capitalization. Thus there is insufficient evidence that in the US financial development causes real GDP. They document that long run causality may vary across countries and that it is possible that the long run relationships themselves exhibit substantial variation. Thus they find that a time series analysis may yield deeper insights into the link between financial development and economic growth than cross country regressions. Finally, they conclude that market failure does not necessarily cause government success and that the effects of financial liberalization depend upon the institutional context of the economy in question and good governance.

One example of a deeper time series analysis is Hansson and Jonung (1997). They investigate the long run relationship between finance and growth in Sweden for the period 1834-1991 applying Johansen cointegration tests to bivariate and multivariate relationships between/ among the variables. They use two new variables, namely human capital and technological progress, in addition to per-capita GDP, per capita financial lending to private sector, and investment per capita. They construct the human capital variable as the increase in years of schooling while technological progress is measured as the number of patent applications. Their results show that the financial system has the largest impact on GDP during the period 1890-1939 and support the view that the role of financial development is significant during the early stages of economic development. They observe no clear-cut causation among the variables for the complete data set. Further, they note that patents are more responsive to financial lending and that the impact of patents on GDP is positive but insignificant for the complete data set.

Another important study is by Shan and Jianhong (2006) which examines the impact of financial development on economic growth in China. They use innovation accounting analysis to investigate the interrelationships between variables in a VAR system for the period 1978-2001. They document that financial development, as measured by total credit, is the second most important variable after the labour force affecting economic growth. Their analysis is based on Granger causality tests which suggest that both financial development and economic growth cause each other, hence confirming bi-directional causality between them. Further, it supports their view that the rapid growth of the Chinese economy is actually due to the development of the rural sector following the reforms in 1979 and not due to the development of the financial sector which started after 15 years of strong economic growth in China. Their results, thus, reject the finance-led growth hypothesis. Although time series studies provide a deeper country-specific analysis, they may illustrate the difficulty of drawing general conclusions on growth from cross-section data.

Most empirical studies use either bank-based or market-based measures of financial development. Levine and Zervos (1998); Beck (2003); and Beck and Levine (2004) perform a remarkable task of bringing together both these measures of financial development. They employ cross-sectional and panel data analysis to show that both the stock market and banking sector development have positive, significant, and robust relationships with the different measures of economic growth. Their results are also robust to various conditioning information sets, measures of financial development and ad hoc methods of identifying outliers.

There are also studies which use micro or firm level data to resolve the finance-growth nexus such as Rajan and Zingales (1998). Their significant contribution is to introduce a new channel by which financial development can affect growth via firms' dependence on external finance; by disproportionately helping those firms which are more dependent on external finance for their growth. They foresee two potential benefits of adopting this approach: it provides a specific testable mechanism and it may resolve the issue of causality by correcting for fixed country effects. In this context they address two important questions: whether financial development reduces the costs of external finance and whether external finance dependent firms grow at a relatively faster rate in financially well well-developed countries. They use industry level as well as macro level annual data on 30 countries for the period 1980-1990.

Their main findings are as follows: First, the effect of financial development on the rate of economic growth is positive and significant through the channel of reducing the cost of external finance to financially dependent firms. Second, financial development may play a significant role in the rise of new firms which may further enhance growth by introducing innovation in the economy disproportionately. Third, the level of financial development can also be a potential factor that may determine the size, composition and concentration of an industry. In sum, they provide evidence of a significant and positive impact of the interaction between an industry's dependence on external finance and the accounting standards of the country in which it operates on industry value added. They use different measures of firms' external dependence on finance to check the robustness of their results.

Acknowledging the significant contributions of Levine-Zervos (1998) and Rajan-Zingales (1998), Manning (2003) criticizes their studies on the grounds of stability and omitted variables bias. He tests the stability of Rajan and Zingales (1998) across OECD and non-OECD sub-samples and then by introducing an interaction variable between a Tiger dummy variable[3] and industry investment

[3] Tiger economies or Asian Tigers may be defined as the group of countries referred to as 'High Performing Asian Economies (HPAEs)' in The World Bank report: "The East Asian Miracle:

intensity (Tiger interaction). Similarly, he tests the stability of Levine and Zervos (1998) by introducing a dummy variable (Tiger dummy) for the group of high-performing Asian economies to their original specification.

He draws three important conclusions: First, there is a need to refine both the theoretical and empirical methods to capture precisely the conditions under which finance affects growth. Second, there is a need to separate out the effect of finance from other institutional, cultural, political, organizational, and environmental factors specific to different countries. Third, it is premature to claim that the measures of financial development can capture its essential features, thus, there is a need to focus on long range historical studies covering a small number of countries at similar stages in their development by incorporating dynamics into their specification.

In contrast to the predominant view in the older literature reviewed above, a number of recent studies find that the relationship between financial development and growth does not remain positive in the presence of financial crisis or when financial development crosses certain limits or threshold levels (see Rousseau and Wachtel, 2011; Arcand et al, 2011). Indeed, the cross-sectional analysis of Rousseau and Wachtel (2011) shows that the relationship between financial development and growth is positive for old data (1960-1989) or for the combined data (1960-2004) only; whereas, it is insignificant or even negative for the latest data set (1990-2004). They show that this change in the relationship is due to financial crisis since the financial liberalization policies adopted by different countries during the 1990s. Further, current empirical evidence shows that a nonlinear relationship may exist between financial development and growth, where finance has a positive and significant effect on growth at its initial levels, whereas its effect becomes negative at higher levels (see cross-sectional results of Arcand et al (2011) and Ductor and Grechyna (2011)).

The above discussion provides no definitive explanation in favour of a positive and significant relationship between financial development and growth. The recent literature raises the possibility that the "old" results may not be robust and hence there is need to re-examining them. Perhaps they did not take sufficient account of country heterogeneity that may be due different financial structures, financial regulations, general rule of law, and the degree of financial deregulation

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Economic Growth and Public Policy" (1993). This group includes Hong Kong, Indonesia, Japan, South Korea, Malaysia, Singapore, Thailand, and Taiwan.

etc. In this chapter, on the one hand we use robust regression methods of quantile regression (QR) and least trimmed squares (LTS) for the sensitivity analysis of five data sets (four from old studies and one extended data set which is more updated) because they can provide us with a clearer picture of the relationship in the presence of heterogeneous data. On the other hand, we add a measure of innovation or R&D in our specification to check whether finance-growth relationship is affected by including R&D. We do this because innovation or R&D has a strong and positive link with financial development (see Morales, 2003; Kim, 2007; Ang, 2011) as well as economic growth (see Aghion and Howith, 1992 ; Howitt and Aghion, 1998; Falk, 2007). Further, R&D may play a proxy role of an omitted variable that might be highly correlated with growth.

1.3. Empirical Methodology

Most empirical studies, such as Beck and Levine (2004) emphasize the direct relationship between financial development and economic growth, thus estimating an econometric model of the form:

$$GROWTH_i = \beta_0 + \alpha' X_i + \beta' FD_i + u_i \qquad (1.1)$$

where GROWTH is real per capita GDP growth, X represents a vector of conditioning variables like initial output, human capital, openness, government size, and inflation etc., FD represents a vector of financial development indicators such as bank credit and turnover ratio etc., and ***u*** is the stochastic error term which is assumed to be *i.i.d.* Together, X and FD define the vector of independent variables used in the regression (1.1), with corresponding coefficient vector $\gamma = (\alpha', \beta')'$.

The model specification of four previous studies (Levine and Zervos, 1998; Beck et al, 2000a; Levine, 2002; and Beck and Levine, 2004) is similar to (1.1); however, we extend it further by including a measure of R&D as a conditioning variable.

In this chapter, an attempt is made to provide sensitivity analyses of some prominent studies in the field viz-a-viz our analysis of extended data using specification of (1.1) and robust regression methods of quantile regression (QR) and least trimmed squares (LTS).

In the following sub-section, we provide an outline of quantile regression (QR) and least trimmed squares (LTS) methods.

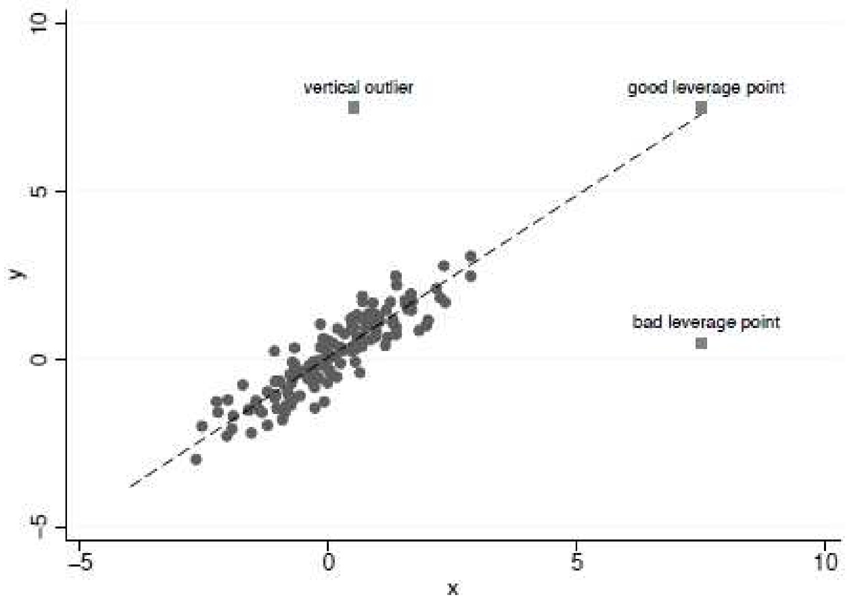
1.3.2. Robustness via Quantile Regression (QR) and Least Trimmed Squares (LTS)

One important difficulty with cross country analysis is that it often contains a heterogeneous group of countries where the existence of outliers is quite likely. Further, the macroeconomic variables especially the indicators of financial development are likely to contain measurement error because there is no precise measure that can capture all the functions performed by a well developed financial system. Moreover, financial development indicators may capture the effect of financial bubbles; although this effect may be minimized through averaging the data across time (see Chinn and Ito, 2006).

Outliers are observations that lie outside the typical relationship between the dependent variable and the independent variables. In simple regression it is easy to detect outliers by viewing their scatter plot. However, it is impossible in multivariate regressions with a large number of observations. Recent literature on robust estimation pays special attention to outliers which are divided into two types. Vertical outliers (unusual observations in Y-direction) may possess very large positive or negative residuals. The second type of outliers is due to observing unusual observations in the X-direction, known as leverages (See Temple, 1999; Zaman et al, 2001; Bramati and Croux, 2007; Finger and Hediger, 2008; Verardi and Croux, 2009). As the OLS estimator assigns equal weight to all observations, the regression line may be tilted towards even a single outlier in X-space, thus changing its slope (see Figure 1.1).

Such unusual observations in the X-direction that affect the regression slope are known as bad leverage points in the literature. Generally, any observation lying far away from the most coherent part of the data in the X-direction is known as a leverage point which may not be an outlier because it doesn’t take into account the Y-direction. For example, any point which is far away from X-points but lying on the regression line won't affect the fit and its slope so it is considered to be a good leverage point (see Figure 1.1).

Figure 1.1: Outliers in Regression Analysis



Source: Verardi and Croux, 2009

As mentioned earlier, detection of outliers in the form of bad leverage points is not straight forward especially if we are dealing with a multivariate model. Two major solutions are proposed in the literature: regression diagnostics and robust estimation. Regression diagnostics like Studentized residuals and Cook's D statistic relate to the calculation of statistics in this context that may be used to pinpoint outliers in the data. These statistics may be useful in case of simple regression or a single outlier in the data; however they are not very useful in multivariate regressions or when the outliers are large in number. The reason is that in case of a large number of outliers, the effect of one outlier is very likely to be masked by the presence of others (see Zaman et al, 2001). The second solution of robust estimation uses those estimators which are not strongly affected by the presence of outliers, like quantile regression (QR), least median squares (LMS), least trimmed squares (LTS), and Maximum-Likelihood-Like-Estimators (M estimators) (see Koenker and Bassett, 1978; Rousseeuw and Leroy, 1987; Rawlings et al, 1998; Zuo, 2005).

Most macroeconomic cross country regressions use OLS for estimation purpose, which minimizes the residual sum of squares. Due to the squaring of residuals, OLS assigns an excessive importance to observations with very large residuals, thus distorting the estimation of regression parameters in the presence of outliers. Hence, OLS method is not useful in the presence of outliers especially when the sample size is small or moderate.

In this chapter, we use quantile regression (QR) and least trimmed squares (LTS) methods as robust alternatives, as suggested by Koenker and Bassett (1978) and Rousseeuw and Leroy (1987) respectively. These are high-breakdown value estimators, where the breakdown of an estimator is defined as:

> "The smallest fraction of contamination that can cause the estimator to take on values arbitrarily far from its value on the uncontaminated data."
> (SAS, 2009, Ch 74)

The breakdown value of an estimator can be considered as a measure of the robustness of the estimator; both the QR (median quantile) and LTS have a high breakdown value of 50%. However, QR is robust to extreme values in response direction (Y-direction) only, whereas LTS is robust to extreme values in Y-direction as well as in covariate space (X-direction). A brief outline of these two methods is given below.

1.3.2.1. Quantile Regression (QR)

The standard linear regression provides a framework that summarizes the average relationship between the dependent variable[4] (Y) and independent variables (Z) based on the conditional mean function, E(Y| Z); whereas, quantile regression (QR) provides a more complete picture about the relationship at different points in the conditional distribution of Y. The quantile q, $q \in (0,1)$, is defined as that value of Y that splits the data into the proportion q below and (1-q) above it. If the cumulative density function (c.d.f.) of the dependent variable (Y) at any specific value q is given as $F(Y_q) = \Pr(Y \leq q)$ then the qth quantile of Y is defined as the inverse function, $Y_q = F^{-1}(q)$.

[4] In order to make our presentation simple, we assume that Y represents our dependent variable (GROWTH), whereas Z includes X and FD as specified in (1.1).

In this context, the median is the best known specific quantile for which q=0.5 and $F(Y_{0.5})$ = 0.5 is the equation whose solution defines the median $Y_{0.5} = F^{-1}(1/2)$. Median regression, also called least absolute deviations (LAD) regression, is more robust to outliers than is mean regression. QR permits us to study the impact of regressors on both the location and scale parameters of the model, thereby allowing a richer understanding of the data. Further, the approach is semi-parametric in the sense that it avoids assumptions about parametric distribution of regression errors. These features make QR especially suitable for heteroskedastic data (see Cameron and Trivedi, 2009; Ch 7).

Contrary to OLS, QR minimizes the sum of absolute values of the residuals, $|r_i|$, that gives the asymmetric penalties: q $|r_i|$ for under prediction and (1-q) $|r_i|$ for over prediction. Standard conditional QR analysis assumes that the conditional QR, $Q_q(Y_q|Z)$, is linear in Z and the qth QR estimator $(\hat{\gamma}_q)$ minimizes over γ_q the objective function:

$$Q(\gamma_q) = \sum_{i:Y_i \geq Z'_i\gamma} q|Y_i - Z'_i\gamma_q| + \sum_{i:Y_i < Z'_i\gamma}(1-q)|Y_i - Z'_i\gamma_q| \qquad (1.2)$$

Where $0<q<1$, and we use γ_q rather than γ to make clear that different choices of q estimate different values of γ. In our estimation of QR, we report coefficient estimates for the median quantile for which q=0.5 and equal weight is placed on prediction for observation with $Y \geq Z'\gamma$ and for observation with $Y < Z'\gamma$; where this special case of median quantile is also known as the least absolute deviations (LAD) estimator that minimizes $\Sigma_i\ |Y_i - Z_i'\gamma_{0.5}|$ (see Cameron and Trivedi, 2009; Ch 7). In addition to the coefficients presented for the median quantile, graphical results are provided relating to the quantile regression estimates for all deciles.

The objective function (1.2) is not differentiable; therefore it is solved using linear programming techniques of simplex as suggested by Armstrong et al (1979). In their simplex algorithm, iteration is required to achieve convergence, in the sense that no additional iteration could improve the solution. In each step of these iterations, the regression plane passes through a set of observations called the *basis*. Initially, a point is replaced in the *basis* to check whether the sum of weighted absolute deviations is improved. If it occurs, a line is printed in the iteration log (see StataCorp., 2009). The linear programming method starts by identifying a good set of observations to make a basis by running a weighted least squares (WLS) regression as suggested by Schlossmacher (1973) and Hunter and Lange (2000).

Koenker and Bassett (1978) show that under mild regulatory conditions and *i.i.d.* setting quantile regression estimator, $\hat{\gamma}(q)$, follows asymptotic normal distribution,

$$\sqrt{n}(\hat{\gamma}(q) - \gamma(q)) \sim N(0, R_2^{-1} R_1 R_2^{-1}) \tag{1.3}$$

where, $\gamma(q)$ is the expected value of $\hat{\gamma}(q)$. $R_2^{-1} R_1 R_2^{-1}$ is the covariance matrix estimated by a method suggested by Koenker and Bassett (1982). $R_1 = X'WW'X$, W is a diagonal matrix with elements,

$$W_{ii} = \begin{cases} \frac{q}{f_{residuals}(0)} & if \quad r > 0 \\ \frac{1-q}{f_{residuals}(0)} & if \ r < 0 \\ 0 & otherwise \end{cases} \tag{1.4}$$

and R_2 is the design matrix X′ X. $f_{\text{residuals (.)}}$ refers to the density of the true residuals. Koenker and Bassett (1978) does not provide any method to obtain a density estimate for the errors in real data, hence a method suggested by Rogers (1993) is used (see StataCorp., 2009).

Rogers's (1993) method is described as follows: first, sort the residuals and locate the observation in the residuals corresponding to the quantile in question and take into account weights if necessary; second, calculate W_n , the square root of the sum of the weights[5]; third, calculate W_s, the sum of weights for all observations in this middle space, typically W_s is slightly greater than W_n thus an adjusted weight is calculated given the number of *k* parameters as W_a=W_s-*k*; fourth, the density estimate is the distance spanned by these observations divided by W_a. Because the distance spanned by this mechanism converges toward zero, this estimate of density converges in probability to the true density (see StataCorp., 2009).

[5] Unweighted data are equivalent to weighted data in which each observation has weight 1, resulting in $W_n = \sqrt{n}$. Similarly, for weighted data, the weights are rescaled so that the sum of the weights is the number of observations, resulting in √n again. For frequency-weighted data, W_n literally is the square root of the sum of the weights. The method locates the closest observation in each direction until the observations are finished, such that the sum of weights for all closer observations is W_n (for details see StataCorp., 2009).

In our estimation of quantile regression, we use the 0.5 quantile (median)[6] which is robust in the sense that it has a high breakdown value of 50%. However, it is robust to extreme values in Y-direction (vertical outliers) only; whereas, it is not robust to the extreme values in the covariate space (X-direction) or leverage points (see SAS, 2009; Ch 72). Therefore, we also employ least trimmed squares (LTS) estimator which possesses the same breakdown value and is robust to the vertical outliers as well as horizontal outliers or leverage points. A brief outline of LTS is given in the following sub-section.

1.3.2.2. Least Trimmed Square (LTS)

The LTS estimator can be written as:

$$\min_{b} \sum_{i=1}^{h} (r^2)_i \tag{1.5}$$

where $(r^2)_i$ are the ascending ordered squared residuals, $0 \le r_{(1)}^2 \le r_{(2)}^2 \le r_{(3)}^2 \le \ldots \le r_{(n)}^2$, and ***h*** is the trimming constant which is defined to be within the range of

$$\frac{n}{2} + 1 \le h \le \frac{3n+p+1}{4} \tag{1.6}$$

where '*n*' is sample size and '*p*' is number of independent variables. Formula (1.5) is similar to OLS except that the largest squared errors are not included in the summation. It effectively uses only the proportion (h/n) of the data with the smallest squared residuals, and hence the breakdown is the proportion of excluded observations.

The statistical package SAS 9.2 (2008)[7] uses a default value of $h = \frac{3n+p+1}{4}$ and a breakdown value of $\frac{n-h}{n}$. For example, in our case of 86 observations and 4 independent variables, SAS 9.2 will choose the default value of ***h*** = 65.75, for which the breakdown value is 23.55%. It means that LTS estimator can withstand up to 23.55% of bad leverage points occurring anywhere in the data. Alternatively, we may choose any other value of ***h*** in the above range as suggested by Rousseeuw and

[6] In our analysis of quantile regressions, we use econometric software STATA 11.0.
[7] In our analysis of LTS estimation, we use the ROBUSTREG procedure in SAS 9.2 which utilizes the FAST-LTS algorithm of Rousseuw and Van Driessen (2000).

Leroy (1987) and can have a breakdown value up to 50%. Following Zaman et al (2001), we use $h = \frac{n}{2} + \frac{p+2}{2}$ and when it gives h < 30, we use h = 30.

1.4. Robustness Analyses of Some Previous Studies

Contrary to the most empirical cross-country studies that do not pay adequate attention to the presence of outliers, we take up this issue by employing the robust regression methods of median quantile regression (QR) and least trimmed squares (LTS) as suggested by Koenker and Bassett (1978) and Rouseeuw and Leroy (1987) respectively. In the following sub-sections we apply these methods to five data sets; four from past studies and one extended data set. In case of past data sets, we followed the information provided by the corresponding studies regarding the availability of original data sets used in their analyses. However, the definitions of variables and sources of data used in extended data analysis are provided in Appendix A1, Table A1.1. Our aim is to check whether the results of above studies are robust to outlier observations in the data. A list of excluded outliers from our LTS analysis is given in Appendix A1, Table A1.2.

1.4.1. Robustness Analysis of Levine and Zervos (1998)

Levine and Zervos (1998) is an important study which incorporates the effects of both the bank-based and market-based measures of financial development and investigates their impact on economic growth using a cross-sectional data of 47 countries for the period 1976-1993[8]. They find that the stock market liquidity and banking development are positively and significantly related to current and future rates of growth, capital accumulation and productivity. They suggest that financial factors are important for economic growth. Their sensitivity analysis shows that their results are robust to the inclusion of different sets of explanatory variables related to legal efficiency and institutional development. Further, they are robust to the inclusion of outlier observations identified by an ad hoc method and scatter plots.

[8] Data are available at the web site http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:20699038~pagePK:64214825~piPK:64214943~theSitePK:469382,00.html

We argue that in multivariate regression models it is almost impossible to identify outliers by using scatter plots or simple methods like Cook's D etc. for the reasons mentioned above. Hence, we employ high breakdown value robust estimators of median quantile regression (QR) and least trimmed squares (LTS) that can withstand up to 50% of the observations as outliers. We replicate their tables which use private credit (PRIV) as a measure of bank development and turnover ratio (TOR), value traded (TVT) and market capitalization (MCAP) as three measures of stock market development.

Models (1), (4) and (7) shown in Table 1.1 exactly replicate the OLS estimates of Levine and Zervos (1998) as given in their tables 3, 4 and 6 respectively. In addition, Table 1.1 shows corresponding models estimated employing QR and LTS techniques. Model (1) in Table 1.1 shows that initial output is negative and significant at 1% level, whereas the measure of human capital (HC) is positive and significant at 10% level. Further REVC has a negative and significant impact on economic growth. Private credit (PRIV) is positive and significant at 2% level, whereas turnover ratio (TOR) is positive and significant at 1% level. As in Levine and Zervos (1998), these results imply that both the bank and market based measures of financial development have positive and significant effects on growth.

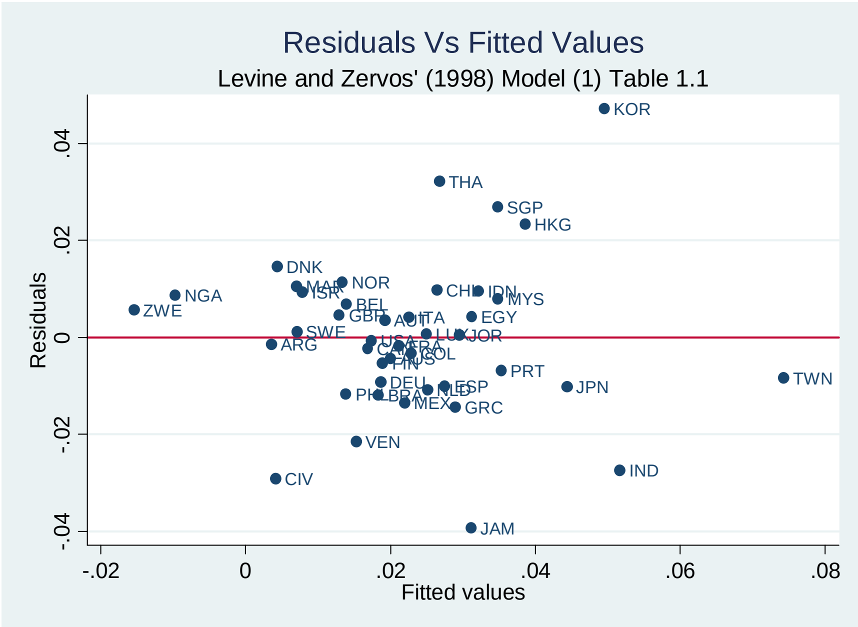
As the OLS estimator can be sensitive to outliers, its estimates given in model (1) may be affected by the presence of extreme observations. For example, if we look at the residuals versus fitted values plot for model (1) the obvious outlier candidate is Korea which lies far away from the predicted line (equivalent to zero value of residuals) (see Figure 1.2). Consequently, the presence of any outlier may distort the OLS fit. In this situation, it may be worthwhile to use robust methods.

Therefore, model (2) provides the median quantile regression (QR) estimates of (1) and shows that the median effect of PRIV on economic growth is positive but insignificant, whereas the sign and significance of TOR remains intact. In addition, Figure 1.3a exhibits the entire quantile regression coefficient estimates for PRIV and TOR for model (2). The 95% confidence intervals are shown by the shaded area. The OLS estimates on PRIV and TOR and their 95% confidence intervals are shown by dashed and dotted lines respectively[9]. Figure 1.3a shows that the role of PRIV is

[9] In our quantile regression plots, the OLS confidence intervals are standard. Therefore, the significance of OLS estimates in these plots does not necessarily match with their significance in Tables that utilize heteroskedasticity consistent standard errors.

positive for most of the quantiles, whereas it is negative for countries having conditional growth rates in the upper tail (around 15%). The coefficient of the turnover ratio (TOR) is positive for all the quantiles, however it is very high and significant only for countries in the upper tail (around 28%). Together, these results imply that for countries with high growth rates, the effect of TOR is greater while that of PRIV is lower than for the majority of countries.

Figure 1.2: Residuals versus Fitted Plot Using Table 1.1



The LTS estimation for the same specification is shown in model (3) which excludes the extreme observations from the data[10]. Model (3) that excludes five outliers (Cote d'Ivoire, Korea, Singapore, Venezuela and Zimbabwe)[11] shows that the estimated coefficients on PRIV and TOR are positive and significant at 5% and 1% level respectively. This result is similar to (1), however removing outliers improves the overall fit which is evident from the value of R^2 that increases from 50% in model (1) to 79% in model (3). Further, we note that the estimate of BMP is negative and significant at 1% level, whereas it is insignificant in model (1).

Model (4) replaces TOR with trading value (TVT) and uses OLS. Findings of model (4) show that both the OLS coefficients of PRIV and TVT are positive and

[10] In our LTS estimation, outliers are defined by the standardized robust residuals that exceed the cutoff value equal to 3.0 in absolute terms.
[11] A list of excluded outliers from our LTS estimation is given in Appendix A1, Table A1.2.

significant at 5% and 1% levels respectively, whereas their median QR estimates as given in model (5) are positive but insignificant. However, we find that the significance of these variables varies over the entire conditional distribution of growth rate (see Figure 1.3b). For example, the estimated coefficient of PRIV is either significant or close to significant at 5% for the 0.3, 0.45, and 0.7 quantiles. Similarly, TVT is approximately significant at 0.3 as well as between the 0.6 and 0.8 quantiles. Further, we note that both the coefficients on PRIV and TVT decrease in countries having the top 10% growth rates. Model (6) shows that the LTS estimates of PRIV and TVT are positive and significant at the 1% level. We observe that although the significance of PRIV improves from 5% in (4) to 1% in (6), the size of both the coefficients on PRIV and TVT decreases a little. Further, the value of R^2 is improves from 47% in (4) to 78% in (6). Moreover, the significance of LY0 and BMP is improved as compared to model (4).

Finally, model (7) in Table 1.1 replaces TOR with MCAP in model (1). The original OLS estimates of Levine and Zervos (1998) in (7) show that the coefficient on PRIV is positive but insignificant, whereas MCAP is positive and significant at 1% level. We observe that the median QR and LTS estimates of PRIV in models (8) and (9) are also positive and insignificant. Further, although MCAP is positive and significant in (8) and (9), its significance decreases in the QR estimation of (8). Figure 1.3c gives the entire quantile regression estimates for PRIV and MCAP for model (8). It shows that the estimated coefficient on PRIV is negative for countries in the extreme lower and upper tails and positive otherwise. However, the coefficient on MCAP remains positive in the entire distribution. We also note that the behaviour of both the estimates on PRIV and MCAP is relatively less stable for countries with very low or very high growth rates.

Overall, our robust analysis of the data and model of Levine and Zervos (1998) shows that the estimated effect of financial development on growth is affected by using methods like QR and LTS that exclude the influence of outlier observations. Further, we note that including market capitalization (MCAP) captures the effect of private credit (PRIV) and renders it insignificant in all the models irrespective of using QR or LTS. Further, trading value (TVT) is sensitive to using QR method. It is also noteworthy that the negative effect of the black market premium is signficant only when outliers are removed using LTS, that seems a consistent finding across the Table 1.1.

Table 1.1: Growth Effects of Private Credit (PRIV), Turnover Ratio (TOR), Trading Value (TVT), and Market Capitalization (MCAP) Using Levine and Zervos' (1998) Data Set, 1976-1993

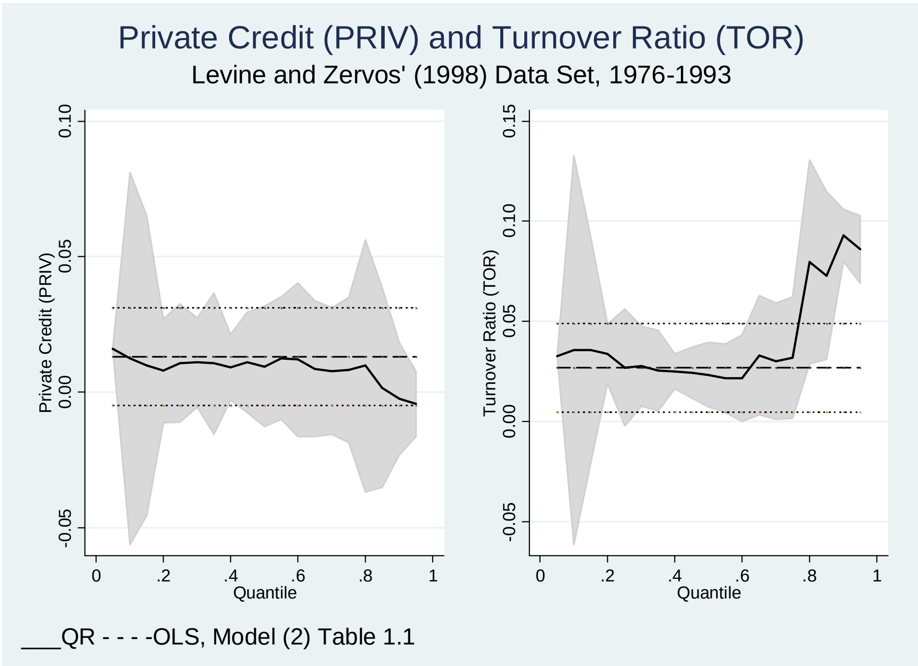
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	**QR**	**LTS**	**OLS**	**QR**	**LTS**	**OLS**	**QR**	**LTS**
LY0	-0.014*** (0.008)	-0.011** (0.038)	-0.008*** (0.003)	-0.013** (0.016)	-0.011* (0.056)	-0.009*** (0.000)	-0.015*** (0.004)	-0.013** (0.027)	-0.009*** (0.000)
HC	0.023* (0.074)	0.013 (0.173)	-0.003 (0.663)	0.021 (0.115)	0.014 (0.204)	-0.000 (0.999)	0.025** (0.044)	0.015 (0.206)	0.002 (0.666)
REVC	-0.035*** (0.003)	-0.035*** (0.000)	-0.025*** (0.000)	-0.030*** (0.001)	-0.027*** (0.009)	-0.072*** (0.000)	-0.027** (0.015)	-0.027** (0.019)	-0.021*** (0.000)
GOV	-0.062 (0.112)	-0.013 (0.824)	0.023 (0.441)	-0.073 (0.116)	-0.015 (0.817)	-0.044 (0.120)	-0.042 (0.271)	0.007 (0.906)	-0.044 (0.141)
INF	-0.007 (0.282)	-0.005 (0.635)	-0.001 (0.880)	-0.007 (0.360)	-0.001 (0.911)	0.012 (0.117)	-0.007 (0.219)	-0.000 (0.990)	-0.008 (0.222)
BMP	-0.000 (0.736)	-0.000 (0.259)	-0.0008*** (0.000)	-0.000 (0.704)	-0.000 (0.596)	-0.001*** (0.000)	-0.000 (0.514)	-0.000 (0.289)	-0.0009*** (0.000)
PRIV	0.013** (0.022)	0.010 (0.389)	0.013** (0.014)	0.015** (0.013)	0.013 (0.231)	0.011*** (0.005)	0.009 (0.155)	0.009 (0.469)	0.005 (0.276)
TOR	0.027*** (0.005)	0.023*** (0.006)	0.022*** (0.000)						
TVT				0.095*** (0.005)	0.045 (0.321)	0.093*** (0.000)			
MCAP							0.023*** (0.001)	0.028** (0.023)	0.019*** (0.000)
Constant	0.046* (0.069)	0.058** (0.027)	0.090*** (0.000)	0.049** (0.046)	0.047 (0.141)	0.097*** (0.000)	0.044** (0.023)	0.055* (0.062)	0.094*** (0.000)
Observations	42	42	37	43	43	34	45	45	39
R-squared	0.50	0.35	0.79	0.47	0.29	0.78	0.46	0.31	0.71

Notes: The p-values are reported in brackets. In case of OLS regressions, the p-values are calculated from White's heteroskedasticity-consistent standard errors. The QR results are median estimates. The p-values in QR models are calculated from Koenker and Bassett' (1978, 1982) standard errors. LTS models employ p-values for chi-square tests. ***, ** and * indicate significance at 1%, 5% and 10% respectively. The dependent variable is real per capita GDP growth. LY0 is log of initial value of real per capita GDP. HC is secondary school enrolment. REVC is revolutions and coups. GOV is initial value of government spending. INF is initial value of inflation. BMP is initial black market premium. PRIV is initial private credit. TOR is initial turnover ratio. TVT is initial trading value ratio. MCAP is initial market capitalization.

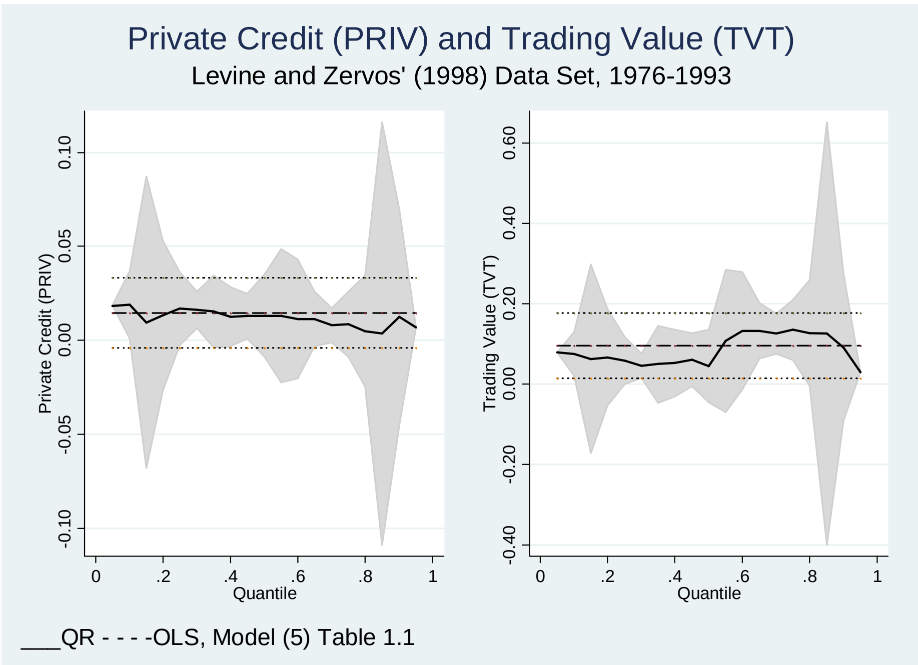
Figure 1.3 OLS and QR Plots of Private Credit (PRIV), Turnover Ratio (TOR), Trading Value (TVT) and Market Capitalization (MCAP)

The following plots illustrate the entire quantile regression estimates for the coefficients of private credit (PRIV), turnover ratio (TOR), total value traded (TVT) and market capitalization (MCAP) in models (2), (5) and (8) in Table 1.1 using Levine and Zervos'(1998) data set. The shaded area indicates the 95% confidence intervals around quantile regression estimates (solid lines). The OLS estimates and their 95% confidence intervals are shown by dashed and dotted lines respectively.

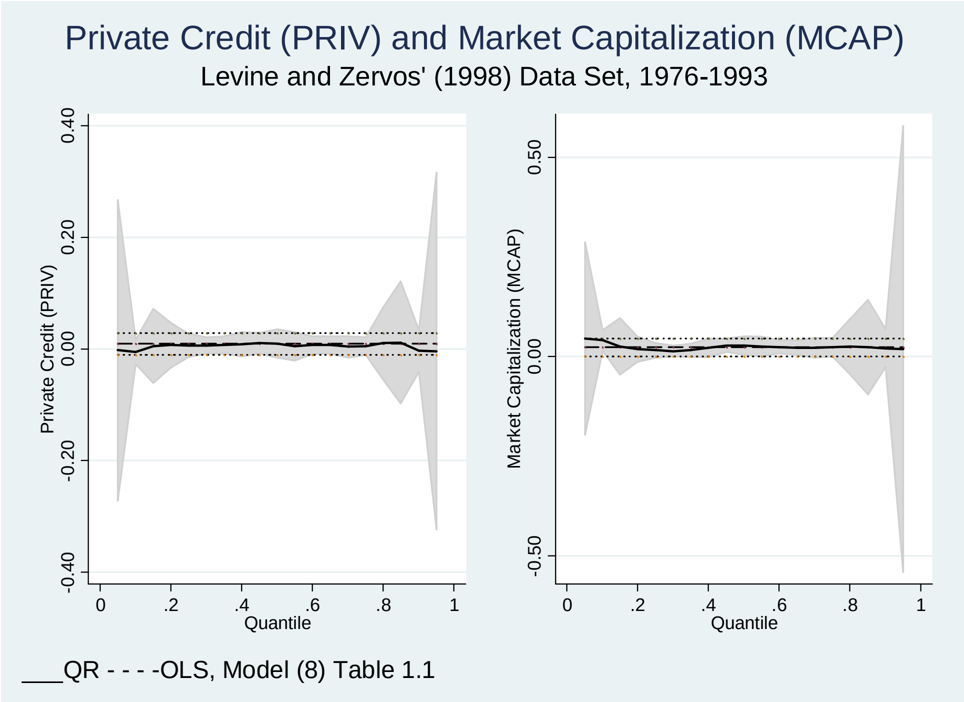
(a)



(b)



(c)



1.4.2. Robustness Analysis of Beck, Levine and Loayza (2000a)

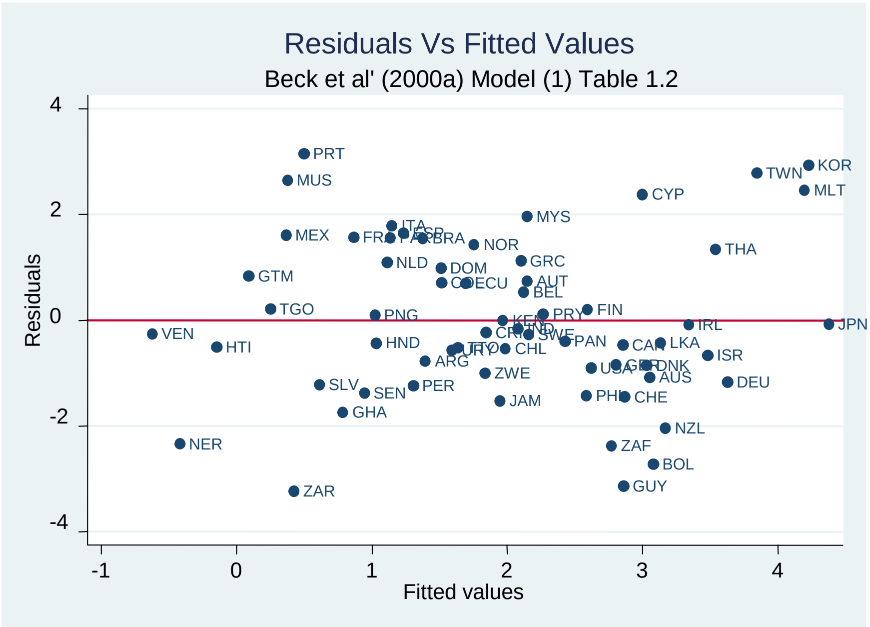
Beck et al (2000a) investigate the impact of financial intermediary development on sources of growth using cross-sectional and panel data for 63 and 77 countries respectively for the period 1960-1995[12]. Their cross-sectional analysis uses the legal origin of countries as instruments for financial intermediary development. Their results show that there exists a positive and strong relationship between financial intermediary development and both real per capita GDP and productivity growth. Their results are robust to different estimation techniques, measures of financial development and conditioning sets. However, they find an ambiguous relationship between financial intermediary development and both capital stock growth and saving rates. Their results support the view that well functioning financial intermediaries improve resource allocation and productivity growth thus enhancing economic growth.

In order to check the robustness of their results by employing QR and LTS methods, we use their growth equations given in Table 5 that provides a summary of

[12] Data are available at the web site http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:20713573~pagePK:64214825~piPK:64214943~theSitePK:469382,00.html

the results from cross-sectional analysis. They use three measures of financial development: liquid liabilities (LLY), commercial central bank (CCB) and private credit (PRIVO) [13]. The definitions and sources of variables can be found in Beck et al (2000a). Their results show that all the measures of financial intermediary development have positive and significant impact on real per capita GDP growth. However, their results may be sensitive to the presence of outliers which is shown by some observation points lying far away from the estimated line in residuals versus fitted plot based on model (1) in Table 1.2 (see Figure 1.4).

Figure 1.4: Residuals versus Fitted Plot Using Table 1.2



First of all, we replicate their cross-sectional GMM estimates using legal origin of countries (English, French, German, and Scandinavia) as instruments of financial development indicators. We obtain cross-sectional GMM estimates by employing *feasible efficient two-step* GMM *estimator* as implemented in IVREG2 module, developed by Baum et al (2002). Our replicated GMM estimates which are similar to those of Beck et al’ (2000a) are given in models (1), (5) and (9) in Table

[13] We use two acronyms for private credit: PRIV represents private credit by deposit money banks to GDP ratio, whereas PRIVO represents private credit by deposit money banks and other financial institutions to GDP ratio.

1.2[14]. Further, we re-estimate their regressions using median instrumental variable quantile regression (IVQR), and least trimmed squares (LTS) methods. We follow Arias et al (2001) to implement IVQR estimation which is similar to standard 2SLS method: where, in the first step we obtain the predicted values of financial development variables by regressing them on legal origin of countries (dummies) and other conditional variables in the model; while, in the second step we use these predicted values of financial development variables as explanatory variables and implement median quantile regression (QR). The same methodology is adopted in a similar analysis by Andini (2011). The first stage results of our IVQR analysis are given in Appendix A1, Table A1.3. We use the similar two-step method in LTS estimation except that we employ least trimmed squares (LTS) in the second stage. Hence, both the IVQR and LTS share the same first stage results.

Using a simple conditioning information set in Table 1.2, model (1) shows that the coefficients on both the initial output (LY0) and human capital (HC) are significant at 1% level, whereas liquid liabilities (LLY) is positive and significant at 5% level. However, the median quantile estimate of LLY in model (2) is positive but insignificant. Figure 1.5a shows that the estimated coefficient on LLY has a positive trend until 0.85 quantile, whereas it decreases for countries in top 15% growth rate. It also shows that the significance of LLY varies across the entire distribution. Model (3) shows the LTS estimation of model (1) which gives similar findings to those of (1); however, the coefficient on LLY increases by approximately 32% and its significance is improved to 1%. Model (4) replaces LLY in model (1) with CCB and shows that the GMM estimate of CCB is positive and significant at 1% level. Further, LY0 is negative and significant at 1% level whereas HCBL is positive and significant at 1% level. The results shown in models (5) and (6) are similar overall to (4). Further, the pattern of quantile regression process for CCB as shown in figure 1.5b is also similar to that of LLY.

Model (7) uses private credit (PRIVO) as a measure of financial development and shows that it has a positive and significant impact (at 1% level) on economic growth. The estimated coefficients of LY0 and HCBL are consistent in sign and significance with previous findings in this table. We observe that the findings of

[14] Our cross-sectional GMM estimates are slightly different from Beck et al (2000a) because the type of cross-sectional GMM used is their study is not clearly mentioned. Hence we were unable to precisely replicate their results.

models (8) and (9) are almost the same as of (7) except minor differences in the magnitude of the coefficients on PRIVO. Further, although the coefficient on PRIVO remains positive in the entire quantile distribution of growth rates as shown in figure 1.5c, its size is relatively low in the extreme lower and upper tails. We also note that its significance varies across quantiles. As far as the validity of the instruments is concerned, throughout our estimation of GMM regressions we are unable to reject the null hypothesis of no correlation between instrumental variables and the error term as shown by the p-values for *Hansen J-test*.

Overall, controlling for simple conditioning information set financial intermediary development indicators have a positive and significant effect on growth except LLY which is not robust to median regression.

Table 1.3 is the extended version of Table 1.2 which includes policy conditioning information set (openness, inflation, government size and black market premium) along with the simple conditioning set of LY0 and HCBL. Model (1) in Table 1.3 shows that the GMM estimate of LLY is positive and significant at 5%, whereas its median estimate in model (2) is larger in size and significant at 10%. Further, the quantile regression process for the estimated coefficient on LLY in model (2) shows a positive trend; where its magnitude is smaller than our median estimate in the lower tail while larger in the upper tail of the distribution of growth rates. The LTS estimate of LLY in model (3) is bit lower in size as compared to (1) and is significant at 5%.

The GMM estimate of CCB in model (4) is positive and significant at 5%; whereas its IVQR and LTS estimates are positive but insignificant as shown in models (5) and (6). Furthermore, the quantile regression process for CCB as shown in figure 1.6b shows similar pattern as for LLY. The GMM estimate of private credit (PRIVO) in model (7) is positive and significant at 1%, whereas its significance decreases to 5% level in IVQR and LTS estimations as shown in (8) and (9). We observe that although the quantile regression process of PRIVO in (8) shows a positive trend, it is little bit flatter as compared to LLY and CCB. Further, we note that the LTS estimation improves the value of R^2 in Table 1.3. We also note that the *Hansen J-test* confirms the validity of instruments used in GMM regressions in Table 1.3 because for all these cases we are unable to reject the null hypothesis of no correlation between the instruments and errors.

Overall, Tables 1.2 and 1.3 show that the effect of private credit (PRIVO) on economic growth is positive and significant. This effect remains robust to different conditioning information sets and robust methods of IVQR and LTS. However, the estimates on LLY and CCB are found to be sensitive to employing robust estimation techniques. The liquid liability to GDP ratio (LLY) is positive but sensitive when IVQR and simple conditioning is used. Further, the behaviour of the estimated coefficient on CCB is robust when simple conditioning is used, but becomes vulnerable to the inclusion of the policy conditioning information set. Further, we note that in models that utilize simple conditioning information set the estimated coefficients on all measures of financial development decrease for countries having growth rates in the extreme upper tail; whereas these coefficients increase for the same quantiles when the policy conditioning information set is added.

Table 1.2: Growth Effects of Liquid Liabilities (LLY), Commercial Central Bank (CCB) and Private Credit (PRIV) Using Beck, Levine and Loayza' (2000a) Data Set, 1960-1995; Simple Conditioning Information Set

Simple Conditioning									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	GMM	**IVQR**	**LTS**	**GMM**	**IVQR**	**LTS**	**GMM**	**IVQR**	**LTS**
LY0	-1.503*** (0.000)	-1.821*** (0.003)	-1.734*** (0.000)	-2.512*** (0.000)	-2.568*** (0.000)	-2.515*** (0.000)	-1.980*** (0.000)	-2.208*** (0.000)	-2.018*** (0.000)
HCBL	2.508*** (0.000)	2.744*** (0.008)	2.486*** (0.000)	2.675*** (0.005)	2.668*** (0.000)	2.843*** (0.000)	1.946*** (0.006)	1.447** (0.031)	1.955** (0.012)
LLY	1.713** (0.015)	1.536 (0.202)	2.263*** (0.006)						
CCB				9.174*** (0.001)	8.010*** (0.004)	8.129*** (0.004)			
PRIVO							2.222*** (0.002)	2.915*** (0.000)	2.354*** (0.002)
Constant	3.468 (0.152)	6.105 (0.161)	3.333 (0.286)	-22.525** (0.015)	-17.163* (0.061)	-18.152* (0.055)	6.597*** (0.004)	6.577*** (0.004)	6.451** (0.012)
Observations	63	63	63	63	63	63	63	63	63
R-squared	0.53	0.15	0.18	-0.23	0.16	0.18	0.51	0.17	0.17
Hansen J-test (p-value)	0.41			0.42			0.75		

Notes: As for Table 1.1. HCBL is log of one plus the average years of schooling in the total population over 25. LLY is log of liquid liabilities. CCB is the log of assets of deposit money banks divided by deposit money banks plus central bank assets. PRIVO is the log of credit by deposit money banks and other financial institutions to the private sector percent of GDP. Legal origin of countries (English, French, German, Scandinavia) are used as instruments of financial development measures; LLY, CCB and PRIVO.

Table 1.3: Growth Effects of Liquid Liabilities (LLY), Commercial Central Bank (CCB) and Private Credit (PRIV) Using Beck, Levine and Loayza' (2000a) Data Set, 1960-1995; Policy Conditioning Information Set

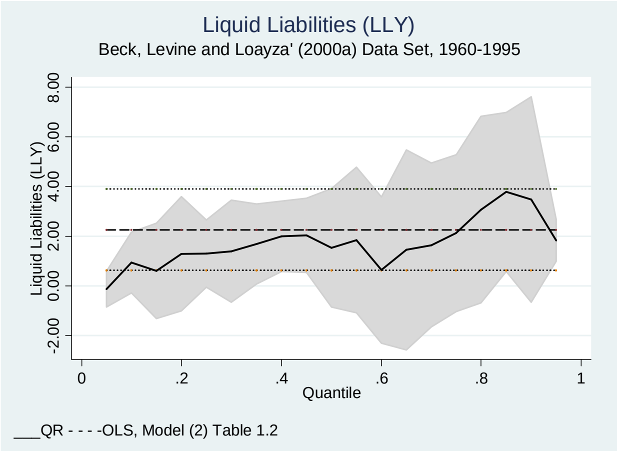
				Policy Conditioning					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	**GMM**	**IVQR**	**LTS**	**GMM**	**IVQR**	**LTS**	**GMM**	**IVQR**	**LTS**
LY0	-1.683***	-1.879***	-1.479***	-2.678***	-2.882***	-1.059**	-1.969***	-1.786***	-1.625***
	(0.000)	(0.004)	(0.000)	(0.000)	(0.006)	(0.026)	(0.000)	(0.001)	(0.000)
HCBL	2.293***	1.932*	0.585	3.459***	3.408***	0.242	1.549*	1.298	0.143
	(0.000)	(0.069)	(0.396)	(0.005)	(0.004)	(0.688)	(0.073)	(0.139)	(0.848)
OPEN	0.372	0.115	0.148	-0.051	-0.330	0.122	0.927**	0.615	0.556
	(0.223)	(0.851)	(0.673)	(0.907)	(0.645)	(0.735)	(0.037)	(0.230)	(0.126)
GOV	-0.710	-1.201	0.499	-1.204	-1.426	0.899	-1.210	-0.971	0.320
	(0.282)	(0.216)	(0.465)	(0.127)	(0.273)	(0.135)	(0.124)	(0.228)	(0.645)
INF	2.051	3.566	2.399	3.064	3.115	0.269	4.267*	4.326	3.309
	(0.306)	(0.335)	(0.253)	(0.430)	(0.487)	(0.883)	(0.088)	(0.141)	(0.138)
BMP	-2.079***	-2.073*	-3.130***	1.953	1.804	-2.670*	-0.145	-0.624	-1.907*
	(0.005)	(0.076)	(0.000)	(0.369)	(0.569)	(0.053)	(0.909)	(0.622)	(0.055)
LLY	2.248**	3.183*	1.940**						
	(0.024)	(0.057)	(0.038)						
CCB				10.264**	10.107	1.665			
				(0.014)	(0.148)	(0.563)			
PRIVO							3.215***	2.788**	2.160**
							(0.010)	(0.024)	(0.018)
Constant	3.673	4.483	3.944	-24.518	-20.406	0.386	2.671	3.788	3.912
	(0.301)	(0.447)	(0.237)	(0.110)	(0.382)	(0.967)	(0.518)	(0.380)	(0.222)
Observations	63	63	56	63	63	50	63	63	56
R-squared	0.60	0.27	0.70	-0.27	0.26	0.74	0.48	0.28	0.72
Hansen J-test (p-value)	0.34			0.30			0.75		

Notes: As for Tables 1.1 and 1.2. OPEN is the log of the sum of real exports and imports of goods and nonfinancial services as share of real GDP. INF is the log of one plus inflation rate. GOV is the log of real general government consumption as share of real GDP. BMP is the log of one plus the black market premium.

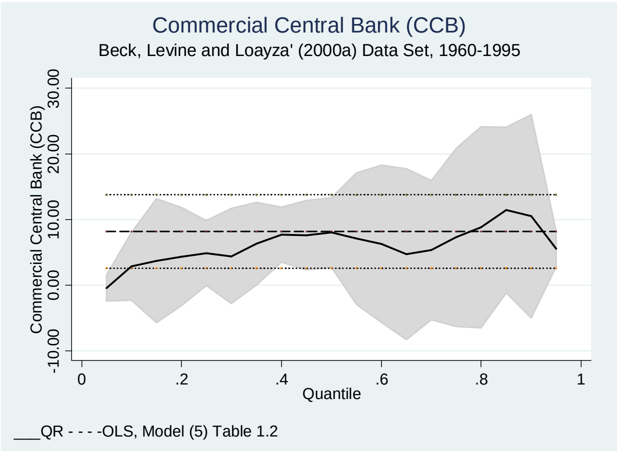
Figure 1.5 OLS and QR plots of Liquid Liabilities (LLY), Commercial Central Bank (CCB) and Private Credit (PRIV); Using Table 1.2

As for Figure 1.3. The following plots illustrate the entire quantile regression estimates for liquid liabilities (LLY), commercial central bank (CCB) and private credit (PRIVO) in models (2), (5) and (8) in Table 1.2 using Beck et al'(2000a) data set.

(a)



(b)



(c)

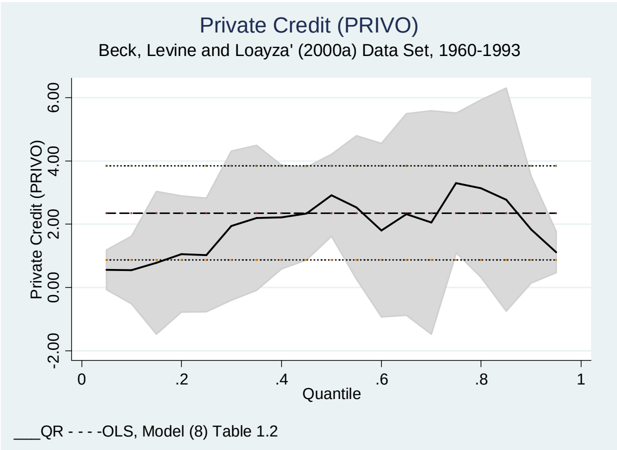
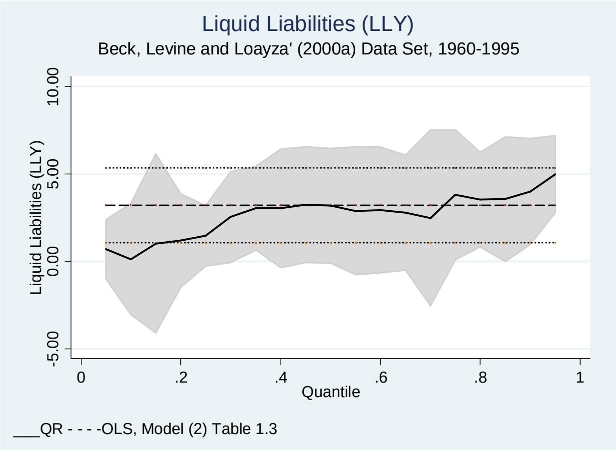


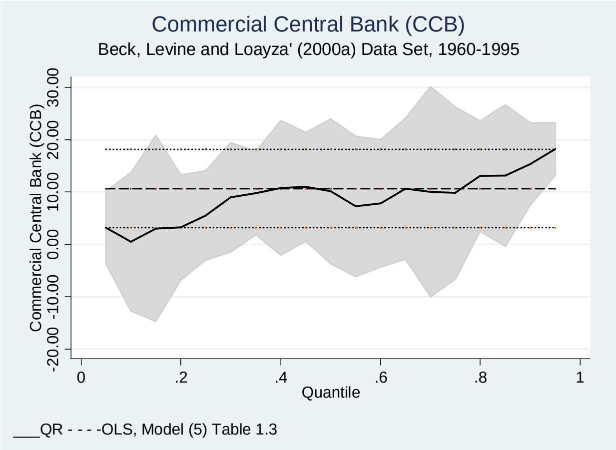
Figure 1.6 OLS and QR plots of Liquid Liabilities (LLY), Commercial Central Bank (CCB) and Private Credit (PRIV); Using Table 1.3

As for Figure 1.3. The following plots illustrate the entire quantile regression estimates for liquid liabilities (LLY), commercial central bank (CCB) and private credit (PRIVO) in models (2), (5) and (8) in Table 1.3 using Beck et al'(2000a) data set.

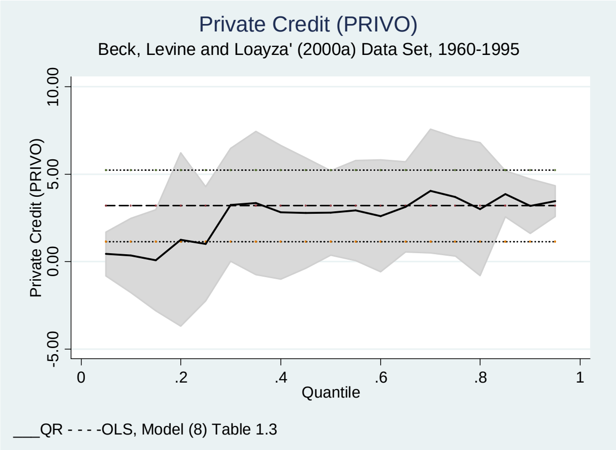
(a)



(b)



(c)



1.4.3. Robustness Analysis of Levine (2002)

Levine (2002) investigates the relationship between financial structure and economic growth using cross-sectional data of 48 countries for the period 1980-1995[15]. He constructs various measures of financial structure and overall financial development. His results do not support just bank-based or market-based views; rather he finds strong evidence in favour of financial services view which emphasizes the quality of financial services produced by the entire financial system. His findings of financial structure are robust to instrumental variables approach, pooling cross-section and time series data, and findings of previous studies using micro data. However, he does not investigate the role of outliers.

In order to test the robustness of his results, we re-estimate his results given in Table IV using the robust methods of QR and LTS. Table IV in his study provides a summary of the growth effects of overall financial development as measured by finance-activity (FA), finance-size (FS), finance-efficiency (FE) and finance-aggregate (FG). The definitions and sources of variables are available in Levine (2002). His results in Table IV (page 420) show that all the four measures of financial development have positive and significant impacts on economic growth, except finance size (FS) which becomes insignificant once the full conditioning information set is included.

The exact replication of Levine's (2002) results is shown by the OLS estimates given in models (1), (4), (7), and (10) in Tables 1.4 and 1.5. Tables 1.4 and 1.5 that use simple and conditioning information sets respectively also show the robust estimates obtained by employing QR and LTS methods. As discussed earlier, the OLS estimates may not portray the real picture because they are sensitive to extreme observations as shown in residuals versus fitted plot of their baseline model (1) in Table 1.4; see Figure 1.7. Figure 1.7 clearly shows the presence of outlier observations in their data like South Africa, Cyprus and Thailand etc that may hinder our understanding of the relationship between financial development indicators and growth. Therefore, we use median regression (QR) and LTS methods that are robust to such outlier observations.

[15] Data are available at the web site http://www.econ.brown.edu/fac/Ross_Levine/Publications.htm

Table 1.4 shows that the OLS as well as the robust estimates of all the measures of financial development are positive and highly significant. However, we note that the LTS estimates of financial development indicators are smaller in size as compared to OLS and QR estimates; where, QR estimates lie between OLS and LTS values. Further, we note that the estimated coefficient on LY0 is significant only in case of employing QR in model (2); whereas, it is insignificant in all other cases. It may suggest that among all the regressions in Table 1.4, only (2) shows evidence of convergence. The quantile regression processes for the estimated coefficients on FA, FS, FE and FG in figure 1.8 show that the coefficients of FA, FE and FG remain positive and significant for most part of the conditional distribution of growth rates; however, the significance of the coefficient on FS varies across quantiles. We also note that the coefficient size on all measures of financial development is little bit higher than the corresponding median values in the upper tail of the distribution.

Figure 1.7: Residuals versus Fitted Plot Using Table 1.4

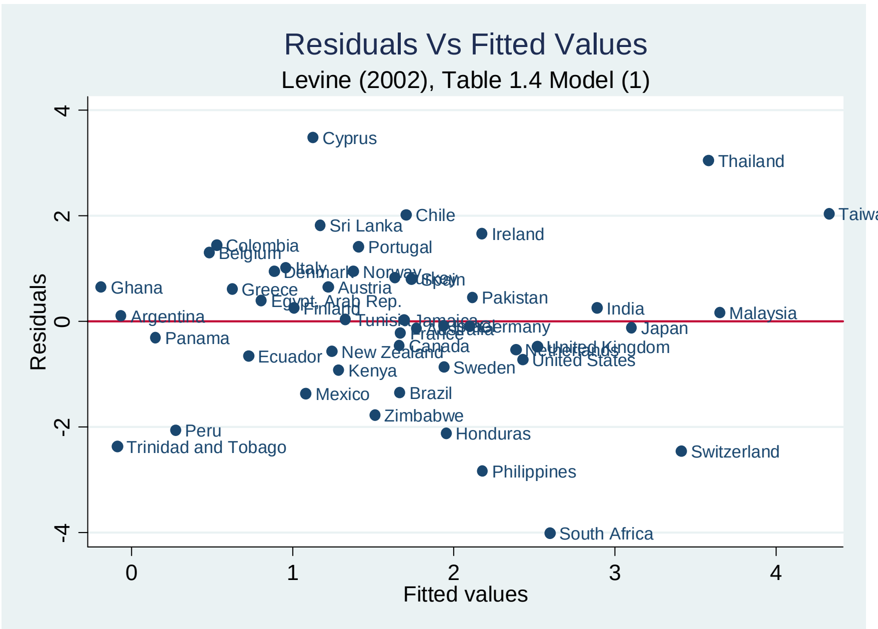


Table 1.5 includes the full conditioning information set. Model (1) in Table 1.5 shows that the OLS estimate of FA is positive and significant at 5% level, whereas its QR and LTS estimates are insignificant, see models (2) and (3). Further, only LTS estimates of LY0, HCBL, OPEN, BMP, CIVIL and REVC are significant as shown in model (3). We also note that LTS estimation of model (1) improves the overall fit as shown by 88% value of R^2. It also shows that the OLS estimate of FA in

model (1) is sensitive to the inclusion of outliers and robust methods. Model (4) replaces FA in model (1) with FS and shows that its impact on economic growth is positive but insignificant. Similarly, the median QR estimate of FS in model (5) is positive but insignificant. However, the estimated coefficient on FS employing LTS is positive and significant at 5% level as shown in model (6). Further, the LTS estimation provides us a clearer picture of the contribution of other control variables in (6) like LY0, INF, BMP, CIVIL, ASSASS and BUREAU; which are otherwise insignificant in (4) and (5). It also improves the overall fit (from 36% to 91% value of R^2).

Models (7) through (12) show that the QR and LTS estimates of FE and FG are consistent in sign and magnitude with their OLS counterparts, however there exist small differences in the size of estimates. We note that in these models QR and LTS perform better with respect to the significance of other explanatory variables and overall fit of the regressions. The quantile regression processes on FA and FS in models (2) and (5) respectively show that their estimated coefficients are positive for most part of the distribution of growth rates, whereas they are negative for countries with very low growth rates; see figures 1.9a and 1.9b. The estimated coefficients on FE and FG are positive for most of the countries, whereas they are closer to zero for countries with very low growth rates; see figures 1.9c and 1.9d. In sum, figure 1.9 shows that all the measures of financial development have wider confidence intervals at both the tails of the conditional distribution of growth rates.

Overall, we note that the estimated coefficient on FA is robust when simple conditioning variables are used, whereas it is not robust in case of using full conditioning information set. The estimated coefficient on FS is clearly a case that can be affected by the presence of outliers as its OLS estimate is insignificant in (4), whereas its LTS counterpart is positive and significant in (6). Furthermore, in this situation using LTS not only improves the significance of finance size (FS) but also the significance of other variables and overall fit of the model. We also note that the coefficients on FE and FG are robust to outliers as well as the conditioning information sets. Finally, we observe that using QR and LTS methods provide us a relatively clearer picture of the relationship between financial development and growth.

Table 1.4: Growth Effects of Finance Activity (FA), Finance Size (FS), Finance Efficiency (FE) and Finance Aggregate (FG) Using Levine's (2002) Data Set, 1980-1995; Simple Conditioning Information Set

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	**QR**	**LTS**	**OLS**	**QR**	**LTS**	**OLS**	**QR**	**LTS**	**OLS**	**QR**	**LTS**
LY0	-0.840 (0.180)	-0.837** (0.049)	0.120 (0.783)	-0.637 (0.350)	-0.925 (0.123)	0.136 (0.778)	-0.568 (0.297)	-0.165 (0.708)	-0.270 (0.489)	-0.775 (0.198)	-0.979 (0.169)	-0.196 (0.627)
HCBL	-0.240 (0.766)	-0.478 (0.479)	-1.018* (0.100)	-0.084 (0.917)	0.639 (0.490)	-0.533 (0.462)	-0.370 (0.635)	-1.014 (0.168)	-0.626 (0.303)	-0.317 (0.679)	0.014 (0.990)	-0.685 (0.241)
FA	0.645*** (0.000)	0.612*** (0.000)	0.435*** (0.000)									
FS				1.374** (0.032)	1.177** (0.010)	0.773** (0.040)						
FE							0.722*** (0.000)	0.721*** (0.000)	0.659*** (0.000)			
FG										1.340*** (0.000)	1.249*** (0.002)	0.988*** (0.000)
Constant	11.633** (0.019)	11.957*** (0.000)	3.820 (0.254)	1.377 (0.702)	3.441 (0.343)	-2.014 (0.483)	6.797* (0.066)	4.341 (0.133)	4.682* (0.071)	8.728** (0.045)	9.974** (0.040)	4.351 (0.122)
Observations	48	48	42	48	48	45	48	48	44	48	48	43
R-squared	0.32	0.17	0.58	0.182	0.09	0.47	0.366	0.22	0.62	0.327	0.17	0.57

Notes: As for Table 1.1. HCBL is average years of schooling in 1980. FA is finance activity=ln(total value traded ratio*private credit ratio). FS is finance size=ln(market capitalization ratio + private credit ratio). FE is finance efficiency=ln(total value traded ratio/ overhead costs). FG=finance aggregate (First principal component of FA, FS and FG).

Table 1.5: Growth Effects of Finance Activity (FA), Finance Size (FS), Finance Efficiency (FE) and Finance Aggregate (FG) Using Levine's (2002) Data Set, 1980-1995; Full Conditioning Information Set

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	**QR**	**LTS**	**OLS**	**QR**	**LTS**	**OLS**	**QR**	**LTS**	**OLS**	**QR**	**LTS**
LY0	-1.192 (0.110)	-0.924 (0.507)	-0.785*** (0.007)	-1.137 (0.159)	-2.134 (0.266)	-4.393*** (0.000)	-0.958 (0.189)	-0.062 (0.758)	-0.839*** (0.000)	-1.135 (0.130)	-0.796** (0.037)	-1.350*** (0.000)
HCBL	0.204 (0.788)	0.280 (0.880)	-1.540*** (0.000)	0.363 (0.674)	1.027 (0.708)	-0.321 (0.398)	0.085 (0.916)	-0.020 (0.947)	-1.444*** (0.000)	0.155 (0.840)	0.123 (0.802)	-1.025** (0.028)
OPEN	0.706 (0.134)	0.805 (0.329)	-0.522* (0.077)	0.683 (0.171)	0.911 (0.613)	-0.336 (0.122)	0.583 (0.229)	0.682*** (0.000)	0.117 (0.498)	0.649 (0.164)	0.743*** (0.006)	0.374 (0.172)
GOV	-1.390 (0.131)	-1.573 (0.439)	-0.0006 (0.999)	-2.058** (0.049)	-2.639 (0.355)	0.156 (0.657)	-1.095 (0.237)	-1.207*** (0.000)	-0.280 (0.406)	-1.454 (0.119)	-1.812*** (0.002)	-0.578 (0.247)
INF	-0.830 (0.483)	-1.179 (0.596)	1.038 (0.231)	-1.019 (0.526)	-0.300 (0.938)	7.053*** (0.000)	-0.541 (0.641)	-0.938*** (0.009)	5.692*** (0.000)	-0.437 (0.723)	-0.766 (0.251)	4.564*** (0.000)
BMP	-0.914 (0.460)	0.266 (0.869)	-9.106*** (0.000)	-1.754 (0.140)	-1.540 (0.446)	-16.919*** (0.000)	-1.097 (0.338)	0.417* (0.062)	-17.171*** (0.000)	-1.091 (0.363)	0.013 (0.973)	-14.961*** (0.000)
CIVIL	-0.020 (0.946)	0.339 (0.345)	-0.637*** (0.000)	0.020 (0.950)	0.251 (0.714)	-0.712*** (0.000)	-0.040 (0.892)	0.279*** (0.000)	-1.416*** (0.000)	-0.044 (0.885)	0.299*** (0.003)	-0.865*** (0.000)
REVC	-1.200 (0.423)	-1.456 (0.557)	3.566*** (0.000)	-1.130 (0.466)	-0.372 (0.925)	0.531 (0.296)	-1.128 (0.453)	-2.173*** (0.000)	5.652*** (0.000)	-1.119 (0.461)	-1.075 (0.128)	3.254*** (0.000)
ASSASS	-0.010 (0.987)	0.943 (0.384)	-0.405 (0.128)	-0.031 (0.961)	0.210 (0.902)	-1.420*** (0.000)	0.036 (0.954)	1.203*** (0.000)	-1.074*** (0.000)	0.012 (0.984)	0.881*** (0.004)	-0.743** (0.015)
BUREAU	0.430 (0.365)	0.412 (0.612)	-0.066 (0.738)	0.534 (0.246)	0.475 (0.684)	0.824*** (0.000)	0.454 (0.342)	0.304** (0.034)	0.068 (0.614)	0.438 (0.347)	0.502** (0.027)	0.136 (0.503)
CORRUPT	-0.200 (0.757)	0.057 (0.959)	0.407 (0.134)	-0.010 (0.987)	0.843 (0.597)	0.188 (0.385)	-0.334 (0.605)	-0.337* (0.060)	-1.010*** (0.000)	-0.226 (0.728)	-0.104 (0.732)	-0.438 (0.106)

Table 1.5: Continued

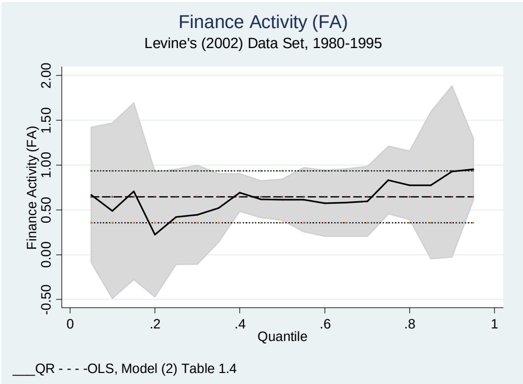
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	**QR**	**LTS**	**OLS**	**QR**	**LTS**	**OLS**	**QR**	**LTS**	**OLS**	**QR**	**LTS**
FA	0.435** (0.039)	0.488 (0.177)	0.006 (0.956)									
FS				0.371 (0.591)	0.493 (0.758)	0.551** (0.011)						
FE							0.527** (0.019)	0.599*** (0.000)	0.451*** (0.000)			
FG										0.897** (0.034)	1.085*** (0.000)	0.647*** (0.001)
Constant	13.452** (0.027)	9.210 (0.392)	13.175*** (0.000)	10.197 (0.121)	13.905 (0.383)	36.598*** (0.000)	9.938* (0.080)	1.947 (0.233)	18.567*** (0.000)	11.862** (0.045)	7.680** (0.018)	18.651*** (0.000)
Observations	48	48	37	48	48	35	48	48	33	48	48	42
R-squared	0.434	0.28	0.88	0.360	0.22	0.91	0.464	0.31	0.92	0.425	0.27	0.90

Notes: As for Tables 1.1 and 1.4. CIVIL is the index of the degree of civil liberties. REVC is the average number of revolutions and coups per year over the period 1980-1993. ASSASS is the number of assassinations per thousand inhabitants. BUREAU is the bureaucratic efficiency. CORRUPT is the measure of corruption.

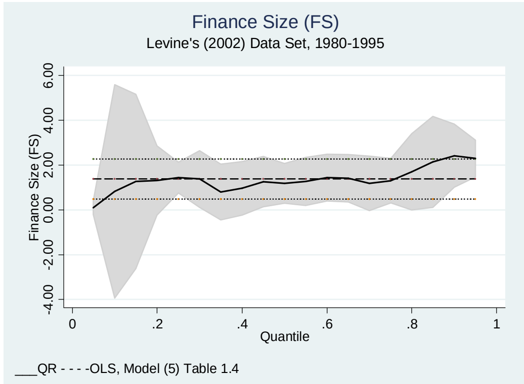
Figure 1.8 Finance Activity (FA), Finance Size (FS), Finance Efficiency (FE) and Finance Aggregate (FG); Using Table 1.4

As for Figure 1.3. The following plots illustrate the entire quantile regression estimates for finance activity (FA), finance size (FS), finance efficiency (FE), and finance aggregate (FG) in models (2), (5), (8) and (11) in Table 1.4 using Levine's (2002) data set.

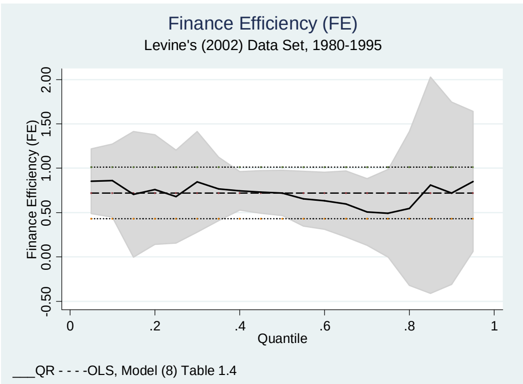
(a)



(b)



(c)



(d)

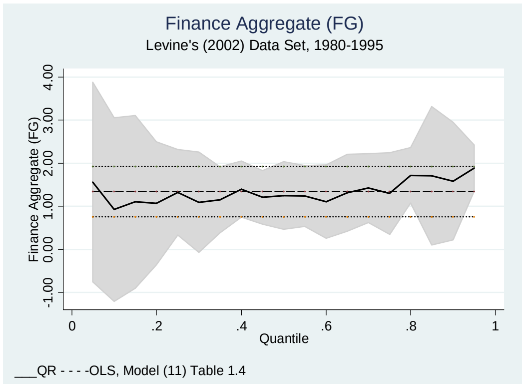
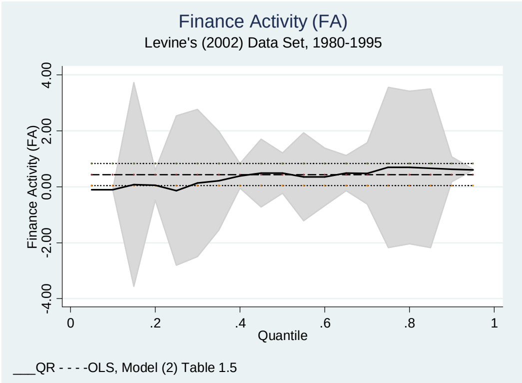


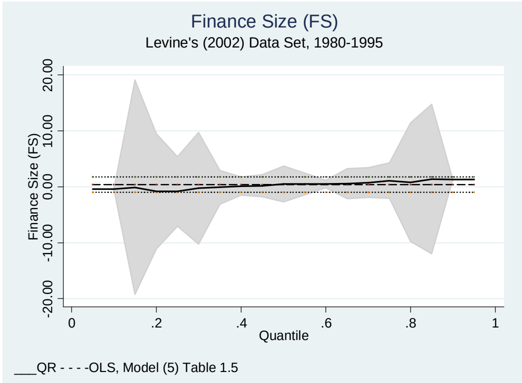
Figure 1.9 Finance Activity (FA), Finance Size (FS), Finance Efficiency (FE) and Finance Aggregate (FG); Using Table 1.5

As for Figure 1.3. The following plots illustrate the entire quantile regression estimates for finance activity (FA), finance size (FS), finance efficiency (FE), and finance aggregate (FG) in models (2), (5), (8) and (11) in Table 1.5 using Levine's (2002) data set.

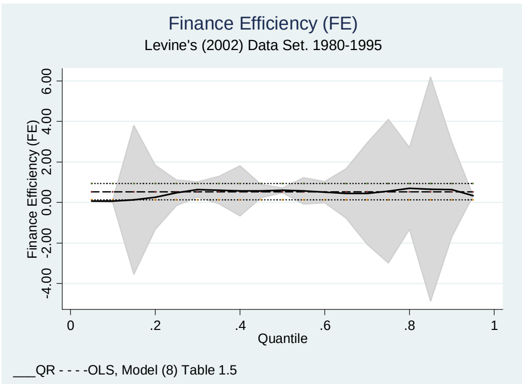
(a)



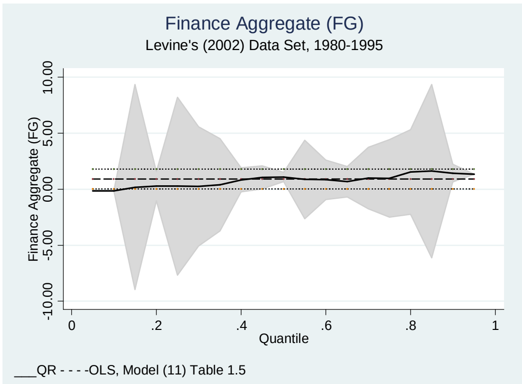
(b)



(c)



(d)



1.4.4. Robustness Analysis of Beck and Levine (2004)

In this section we use Beck and Levine's (2004) cross country data set on 40 countries averaged over the period 1976-1998[16] to see whether their results are affected by the presence of outlier values. Table 2 in their study shows the OLS regression results for five different specifications, model (1) in Table 1.6 being their base line model. We attempt to replicate their regression (1) using full sample of 40 observations, and then re-estimate it using median quantile regression (QR) and LTS methods that provide estimates excluding the effect of outliers in data. Table 1.6 shows that the resulting estimates of model (1) are same as reported by Beck and Levine (2004). Both the coefficients of PRIV and TOR are positive and significant at 1% and 5% respectively. Their findings are consistent with a similar analysis by Levine and Zervos (1998) as discussed in sub-section 1.4.1.

However, their data is not free from outlier observations that may hinder our understanding of the effects of PRIV and TOR on growth (see Figure 1.10). Figure 1.10 indicates that Chile, Korea, South Africa and Philippines have relatively large residuals and lie far away from the prediction line (zero residuals). The presence of such observations may distort the OLS regression estimates. However, as noted earlier it is difficult to detect outliers or bad leverage points by scatter plots because in multivariate analysis the outliers may mask the presence of each other. Thus, we use robust regression methods that provide a clearer picture and exclude the effects of extreme observation points in the data.

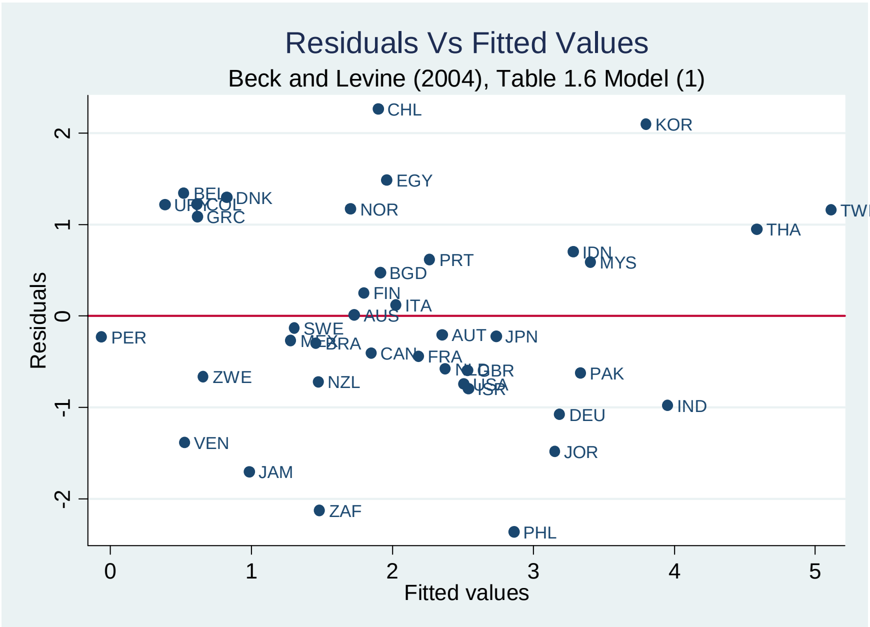
Model (2) in Table 1.6 re-produces the results of model (1) using median quantile regression (QR) and shows that the coefficient on PRIV is positive and significant at 1% level which is consistent with model (1) and earlier study of Levine and Zervos (1998). However, the coefficient on TOR is positive but insignificant. The quantile regression process for PRIV shows that the estimated coefficient on PRIV decreases in the lower tail of the distribution, whereas it increases from approximately 0.2 quantile to 0.8 quantile and again falls in top 20% of the distribution of growth rates (see Figure 1.11). However, the behaviour of TOR is opposite to that of PRIV; it falls in the lower part (approximately 45%) of the distribution, whereas it increases for countries having approximately top 55% growth

[16] Data are available at the web site http://www.econ.brown.edu/fac/Ross_Levine/Publications.htm

rates. Further, PRIV is significant in most of the upper parts of growth rates, whereas TOR remains insignificant in these parts. However, TOR is significant for most of the countries having growth rates below 0.4 quantile.

Model (3) shows the re-estimation of (1) using least trimmed squares (LTS) method. After applying LTS we identify five outlier observations of Jamaica, Korea, Taiwan, Venezuela and South Africa. The LTS estimates in model (3) exclude these outlier observations. Model (3) shows that the coefficient size of PRIV increases from 1.46 to 1.53 and is significant at 1%; whereas, the coefficient size of TOR decreases from 0.790 to 0.047 and becomes insignificant. This finding is partially different from the robust analysis of a similar study by Levine and Zervos (1998) who show that TOR is positive and significant. Further, the coefficient of determination, R^2, for LTS is higher (0.63) as compared to 0.54 in model (1).

Figure 1.10: Residuals versus Fitted Plot Using Table 1.6



Overall, comparing Beck and Levine's (2004) OLS results of model (1) with that of robust regression results of models (2) and (3), we show that the magnitude of the coefficient on PRIV improves, whereas its significance remains the same. However, the coefficient on TOR decreases in size and becomes insignificant. Further, the value of R^2 increases from 54% to 63%. Hence, according to our robust estimation in (2) and (3) only PRIV plays a positive role in promoting economic growth which is contrary to Beck and Levine (2004) who emphasize the positive role of banks as well as stock markets in enhancing growth.

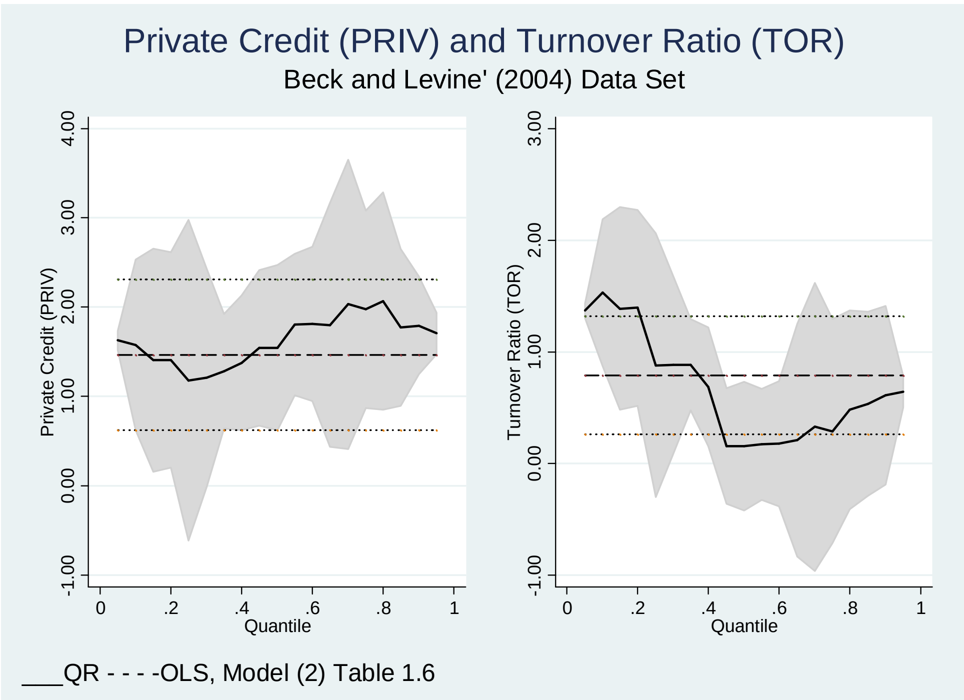
Table 1.6 Growth Effects of Private Credit (PRIV) and Turnover Ratio (TOR) Using Beck and Levine' (2004) Data Set, 1976-1998; Base Line Model

	(1)	(2)	(3)
	OLS	**QR**	**LTS**
LY0	-0.853** (0.017)	-0.540* (0.072)	-0.555** (0.013)
HCBL	0.539 (0.604)	-0.376 (0.687)	-0.187 (0.786)
PRIV	1.465*** (0.000)	1.545*** (0.002)	1.532*** (0.000)
TOR	0.790** (0.025)	0.155 (0.588)	0.047 (0.849)
Constant	0.341 (0.811)	1.004 (0.487)	1.386 (0.195)
Observations	40	40	35
R-squared	0.54	0.24	0.63

Notes: The p-values calculated from White's heteroskedasticity-consistent standard errors are reported in brackets. LTS models employ p-values for chi-square tests. ***, ** and * indicate significance at 1%, 5% and 10% respectively. The dependent variable is real per capita GDP growth. LY0 is log of initial value of real per capita GDP. HCBL is the average years of schooling. PRIV is the private credit by deposit money banks percent of GDP. TOR is the stock market turnover ratio. Models (2) and (3) employ robust methods of median quantile regression (QR) and least trimmed squares (LTS).

Figure 1.11 Private Credit (PRIV) and Turnover Ratio (TOR); Using Table 1.6

As for Figure 1.3. The following plots illustrate the entire quantile regression estimates for private credit (PRIV) and turnover ratio (TOR) in model (2) in Table 1.6 using Beck and Levine' (2004) data set.



1.5. Robust Analysis of Extended Data Set, 1997-2005

In this section we discuss the estimation and results of our extended data set which is more updated and extended across variables and countries. As the recent literature shows that the effect of financial development on growth does not remain intact for recent data which may contain the effects of financial crisis (see Rousseau and Wachtel, 2011); our data set provides an opportunity to explore this issue further. In this section, we provide the robust analysis of finance-growth relationship using an extended data set and the specification of Beck and Levine (2004) which is more recent (among data sets being used) and uses both the bank and market based measures of financial development. Our extended data set covers 86 developing and developed countries and is more recent (1997-2005) as compared to Beck and Levine (2004) who utilize a data of 40 countries over the period 1976-1998. Further, we extend it across variables by adding a measure of R&D. Further, we also introduce a measure of R&D into the above specification which may represent an omitted variable that is highly correlated with growth. The following sub-sections discuss our data, estimation and results.

1.5.1. Data

Our cross sectional analysis consists of annual averages of 86 countries for the period 1997-2005. Due to data limitation, the selection of countries and time period is purely based on the availability of annual observations on Gross Domestic Expenditures on R&D as a percentage of GDP (GERD). Our data set well represents all the regions (6 countries from East Asia and Pacific, 19 from Europe and Central Asia, 31 from OECD and high income non-OECD, 15 from Latin America and Caribbean, 5 from Middle East and North Africa, 5 from South Asia, and 5 from sub-Saharan Africa)[17]. In Appendix A1, Table A1.5 shows that the average growth rate of sample countries is 2.88 percent that varies in the range of -0.78 to 9.15 percent.

Following Beck and Levine (2004), we use real per capita GDP growth (GROWTH) as a measure of economic growth. For financial sector development we use two measures: domestic credit to private sector divided by GDP (PRIV) and stock market turnover ratio (TOR), where the former represents a bank-based

[17] List of sample countries with their geographic location is given in Appendix A1, Table A1.4.

measure, whereas the latter represents a market-based measure of financial development. These measures are now well documented in many empirical studies on financial development and economic growth (see Levine and Zervos, 1996, 1998; Beck and Levine, 2004). Besides taking logs which is usually done to reduce nonlinearity in the data, our data plots show that there may exist a nonlinear relationship between indicators of financial development (PRIV and TOR) and growth (see Figure 1.12); this issue is taken up in chapter 2.

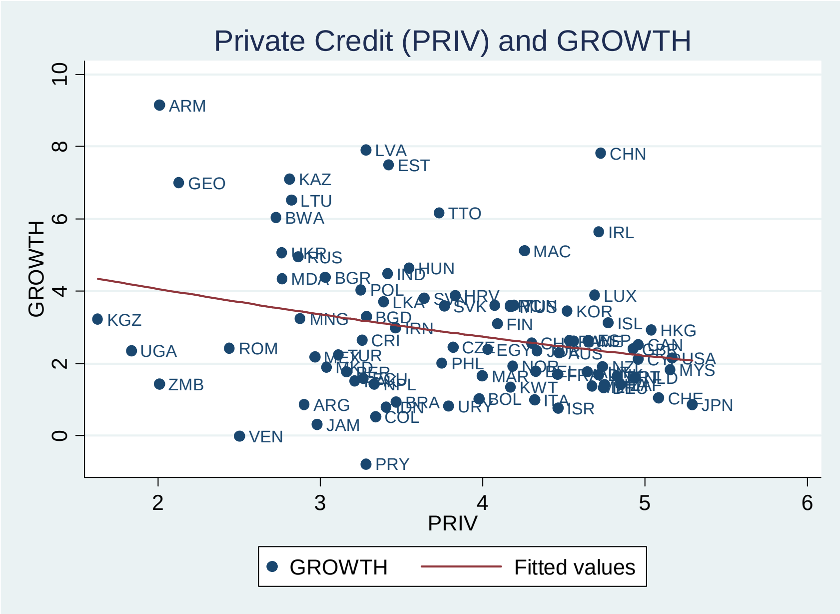
We use R&D expenditures to GDP ratio (GERD) as a proxy of R&D. R&D expenditures account for 50 percent or more of spending on wages and salaries of highly educated scientists and engineers who contribute in the production of an intangible asset, the firm's knowledge base. Consequently, the firms use their knowledge base to introduce innovation which in turn enhances economic growth (see Hall, 2002; Hall and Lerner, 2009). Moreover, there is theoretical and empirical evidence that shows a positive strong relationship between R&D expenditures and GDP growth (see Freire-Seren, 2001). Recent literature shows that financial and technological innovations evolve endogenously to promote growth, where the former may cause excess finance and result in crisis thus leaving a negative impact on finance-growth relationship (see Michalopoulos et al, 2010; Wachtel and Rousseau, 2011; Arcand et al, 2011; Ductor and Grechyna, 2011). Therefore, we include a measure of innovation or R&D that may represent an omitted variable that might have an important link with growth.

We include all countries for which at least one observation is available on GERD[18]. Following Beck and Levine (2004), we use initial real per capita GDP (LY0) to control for convergence and secondary school enrolment (HC) to control for human capital accumulation. The detail of all variables and sources is given in the Appendix A1, Table A1.1.

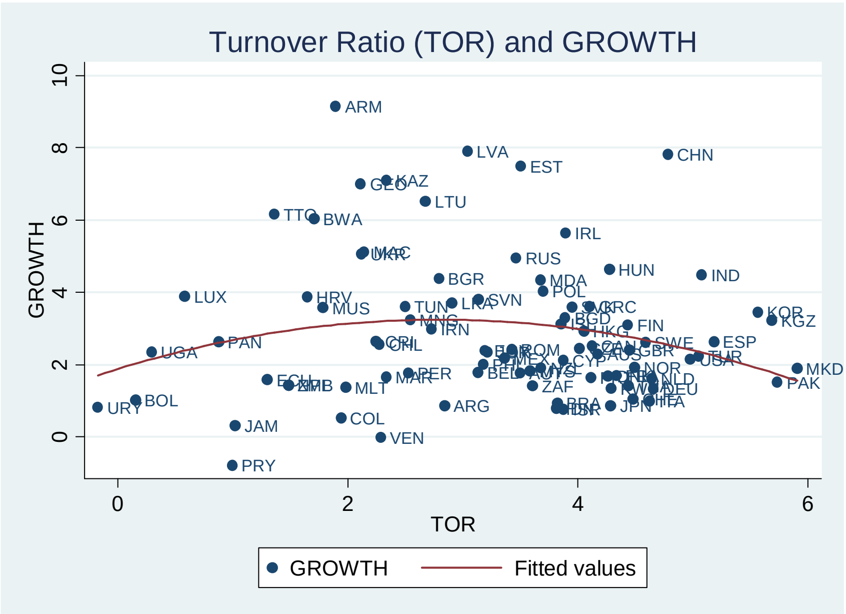
[18] There are four countries with only one observation: Botswana, Jordon, Moldova, and Nepal. The countries with two observations are Indonesia, Jamaica, Philippines, Sri Lanka, and Switzerland. Rest of the countries have four or more observations. In our sample, most of the countries contain full sample of nine observations.

Figure 1.12: Scatter Plots of Private Credit (PRIV) and Turnover Ratio (TOR) against Economic Growth (GROWTH)

(a)



(b)



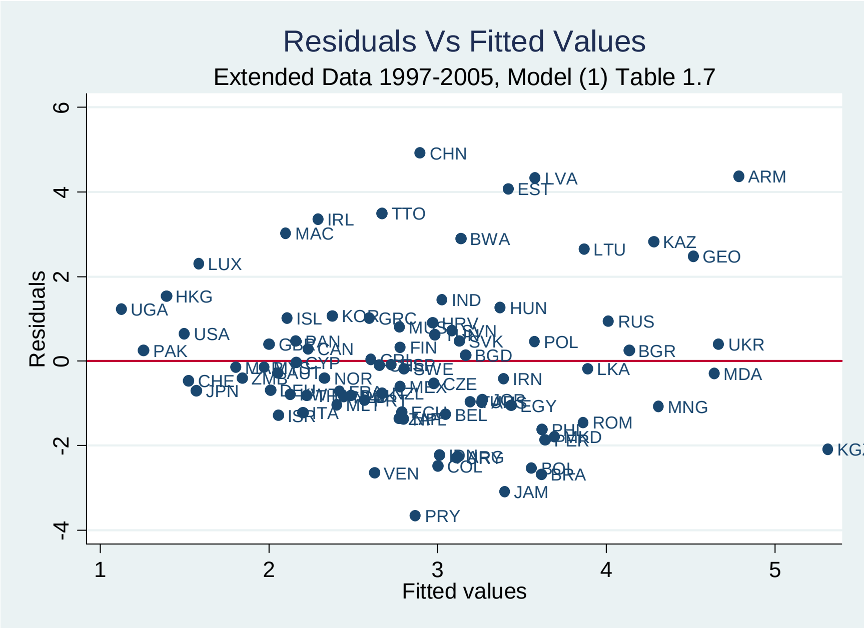
1.5.2. Estimation and Results

We aim to re-estimate Beck and Levine' (2004) baseline regression using their specification and our extended data set. We choose their specification because it is more recent in the group of our selected studies discussed above. Further, they use both the bank and market based measures of financial development. Moreover, they confirm their cross-sectional findings using more sophisticated techniques of one-step and two-step system GMM estimators for dynamic panel data models. Hence models (1) through (3) in Table 1.7 use Beck and Levine' (2004) specification similar to the models discussed in section 1.4.4. Further, we add into their specification a measure of R&D that may represent an absent variable that might be highly correlated with growth; see models (4) through (6). Table 1.7 reports OLS as well as median quantile regression QR and LTS estimates.

Model (1) in Table 1.7 shows that the coefficient on initial output (LY0) is negative and significant which is consistent with convergence literature as well as above findings. Further, the coefficient on HC is positive and significant at 1% level which is insignificant in Table 1.6. The coefficient on PRIV is negative and insignificant, whereas TOR is positive but insignificant. These results are contrary to the above findings particularly of Beck and Levine (2004). The residuals-versus-fitted plot of model (1) shows that there are many observations that may have larger residuals (see Figure 1.13). Consequently, these outliers may hinder our understanding of the finance-growth relationship.

Therefore, we re-estimate model (1) using median quantile regression (QR) and least trimmed squares (LTS) estimators. For example, model (2) uses QR and shows that both the coefficients of PRIV and TOR are negative and insignificant. Their quantile regression processes for model (2) are shown in Figure 1.14a. Figure 1.14a shows that the estimated coefficient on PRIV exhibits a concavity pattern in quantiles below 0.8, whereas it sharply increases for countries having top 20% growth rates in our sample. Further, we note that for most of the countries PRIV is negative. Similarly, TOR also exhibits concavity pattern; whereas it is positive in the lower part of the distribution while negative in the upper part. We note that PRIV and TOR are insignificant for most of the quantiles.

Figure 1.13: Residuals versus Fitted Plot Using Table 1.7



The LTS estimation of model (3) which excludes four outliers of China, Estonia, Latvia and Paraguay shows that the impact of PRIV on growth is negative and significant; whereas, TOR is negative but insignificant. This finding is consistent with Rousseau and Wachtel (2011) for their regression over the period 1990-2004 which may incorporates the negative effects of financial crisis during this period on finance-growth relationship. Furthermore, the fit of model (3) is relatively better than (1) and (2) which is shown by relatively higher value of R^2.

In model (4) Table 1.7, we add a measure of R&D (GERD) as a proxy of an omitted variable that might have strong relationship with growth and may explain the changing behaviour of the finance-growth relationship. Model (4) shows that the OLS estimates of PRIV and TOR are negative and insignificant, whereas GERD is positive but insignificant. Model (5) re-estimates (4) using QR and gives similar results. The quantile regression processes on PRIV and TOR for model (5) exhibit similar patterns as of (2); see Figure 1.14b. However, the quantile regression process on GERD in model (5) shows a concavity pattern, where it is positive approximately until quantile 0.7 and negative after that (see Figure 1.14c). The LTS estimates of model (6) that exclude the effects of outliers show that the coefficient on PRIV is negative and insignificant, whereas TOR is positive and insignificant. However, GERD has a positive and significant (at 1% level) impact on growth. The above results may suggest that GERD not only has a strong effect on economic growth, it also captures the effects of financial development indicators. Further, the signs and significance of LY0 and HC remain similar to (4) except small differences in their magnitudes.

Finally, we add other control variables which are common in the literature, namely investment share of GDP (INV), openness (OPEN), government size (GOV) and inflation (INF) into baseline model (1), leading to model (7). Model (7) in Table 1.7 shows that the OLS estimate of PRIV is negative and significant at 1% level, whereas TOR is negative but insignificant. Further, GERD is positive but insignificant. Similarly, in model (8), the median quantile (QR) estimate of PRIV is negative and significant at 10%, whereas TOR is negative but insignificant. However, the estimated coefficient on GERD is positive and significant at 5% level. We observe that the coefficient on PRIV is smaller in (8) as compared to its value in (7). The estimates in model (9) are obtained by employing LTS; which shows that the estimated coefficient on PRIV is negative and significant at 1% level, whereas TOR remains negative and insignificant. Further, GERD is positive and significant at 5% level. We note that the coefficient on PRIV in (9) has similar magnitude as in (8). We also note that employing LTS improves the overall fit which is evident from increased value of R^2 (from 42% in (7) to 69% in (9)).

Overall, the above results show that the robust estimates of PRIV are negative and significant, except one case where we add GERD in the specification of baseline model. Further, the effect of TOR on growth remains negative but insignificant in most of the cases. These findings are consistent with Rousseau and Wachtel's (2011) cross-sectional analyses of recent data sets. Rousseau and Wachtel (2011) show that the positive and significant effect of financial development on growth is valid for old data set only (before 1990s); that disappears in the recent data, may be due to repeated crisis after 1990s. Therefore, the negative and significance impact of PRIV on growth in Table 1.7 can be explained in this sense. Moreover, we note that our measure of innovation or R&D (GERD) may represent a missing variable which is highly correlated with growth and may have important implications for finance-growth relationship. This issue is dealt in detail using panel data and more sophisticated econometric techniques in chapter 2.

Table 1.7 Growth Effects of Private Credit (PRIV) and Turnover Ratio (TOR) Using Extended Data Set, 1997-2005

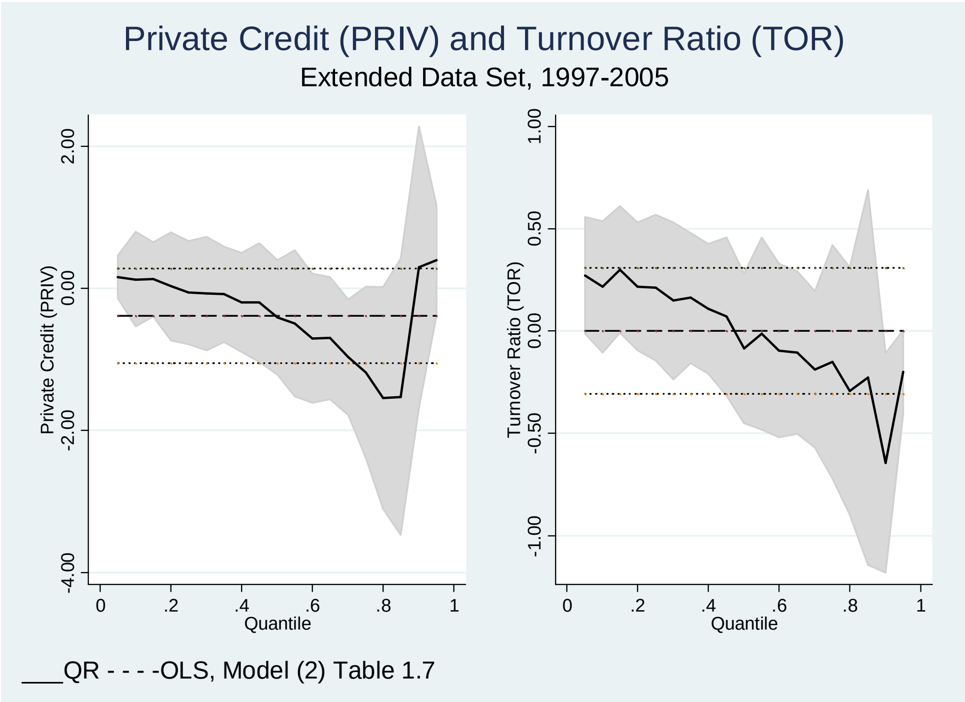
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	**QR**	**LTS**	**OLS**	**QR**	**LTS**	**OLS**	**QR**	**LTS**
	Baseline Model			**Adding GERD**			**Adding GERD and other controls**		
LY0	-0.558** (0.047)	-0.516* (0.078)	-0.343 (0.115)	-0.640** (0.042)	-0.610 (0.115)	-0.628*** (0.000)	-0.542** (0.041)	-0.551* (0.098)	-0.344* (0.070)
HC	2.543*** (0.000)	1.926** (0.030)	2.198*** (0.001)	2.556*** (0.000)	1.690* (0.076)	1.500*** (0.002)	2.475*** (0.000)	1.928** (0.035)	1.655*** (0.003)
INV							2.867** (0.025)	2.640** (0.042)	2.528*** (0.001)
OPEN							0.819** (0.022)	1.119** (0.031)	0.862*** (0.003)
GOV							-0.621 (0.302)	-0.775 (0.384)	-0.309 (0.547)
INF							-0.716** (0.025)	-0.355 (0.334)	-0.209 (0.334)
PRIV	-0.386 (0.351)	-0.407 (0.318)	-0.574* (0.058)	-0.409 (0.309)	-0.270 (0.595)	-0.046 (0.840)	-1.077*** (0.005)	-0.887* (0.056)	-0.839*** (0.002)
TOR	0.001 (0.995)	-0.085 (0.643)	-0.110 (0.420)	-0.044 (0.790)	-0.062 (0.796)	0.066 (0.514)	-0.017 (0.911)	-0.182 (0.335)	-0.034 (0.761)
GERD				0.572 (0.331)	0.814 (0.419)	1.120*** (0.009)	0.850 (0.137)	1.732** (0.042)	0.994** (0.049)
Constant	-2.288 (0.185)	0.274 (0.927)	-1.581 (0.487)	-1.762 (0.285)	0.912 (0.761)	0.176 (0.915)	-9.407** (0.037)	-8.690* (0.077)	-9.391*** (0.003)
Observations	86	86	82	86	86	75	86	86	78
R-squared	0.19	0.09	0.22	0.20	0.10	0.29	0.42	0.24	0.69

Notes: As for Tables 1.1, 1.5 and 1.6. All the regressions are estimated using extended data set for 86 countries over the period 1997-2005. Models (1)-(3) use Beck and Levine's (2004) specification for cross-section regressions using robust standard errors. INV is investment share of GDP. GERD is gross domestic expenditures on R&D percent of GDP.

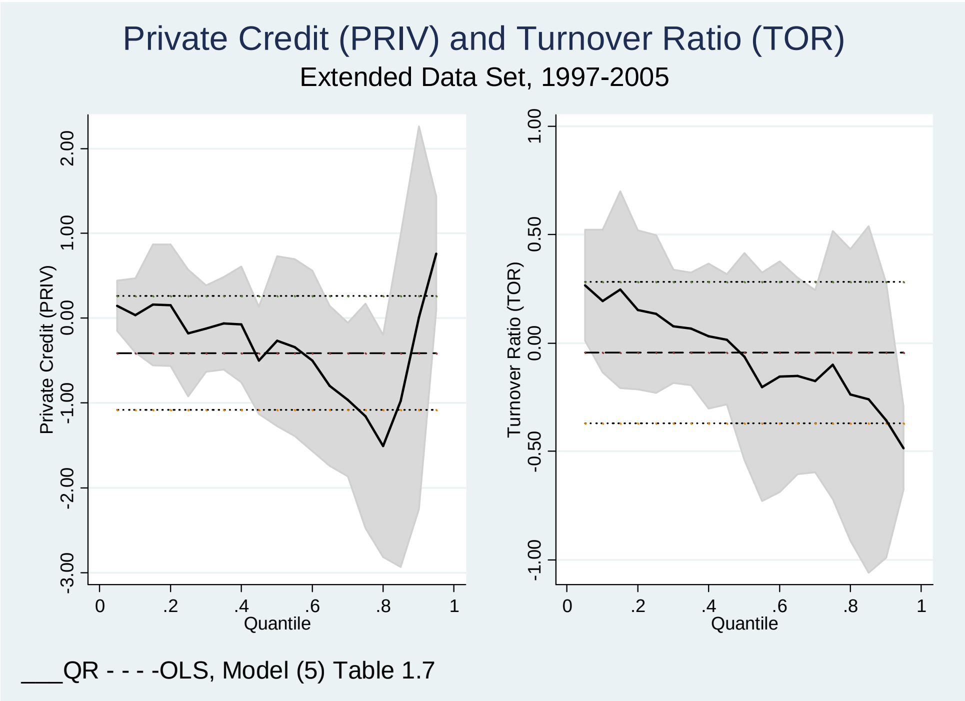
Figure 1.14 Private Credit (PRIV) and Turnover Ratio (TOR); Using Table 1.7

As for Figure 1.3. The following plots illustrate the entire quantile regression estimates for private credit (PRIV), turnover ratio (TOR) and R&D expenditures to GDP ratio (GERD) in models (2) and (5) in Table 1.6 using Extended Data Set, 1997-2005.

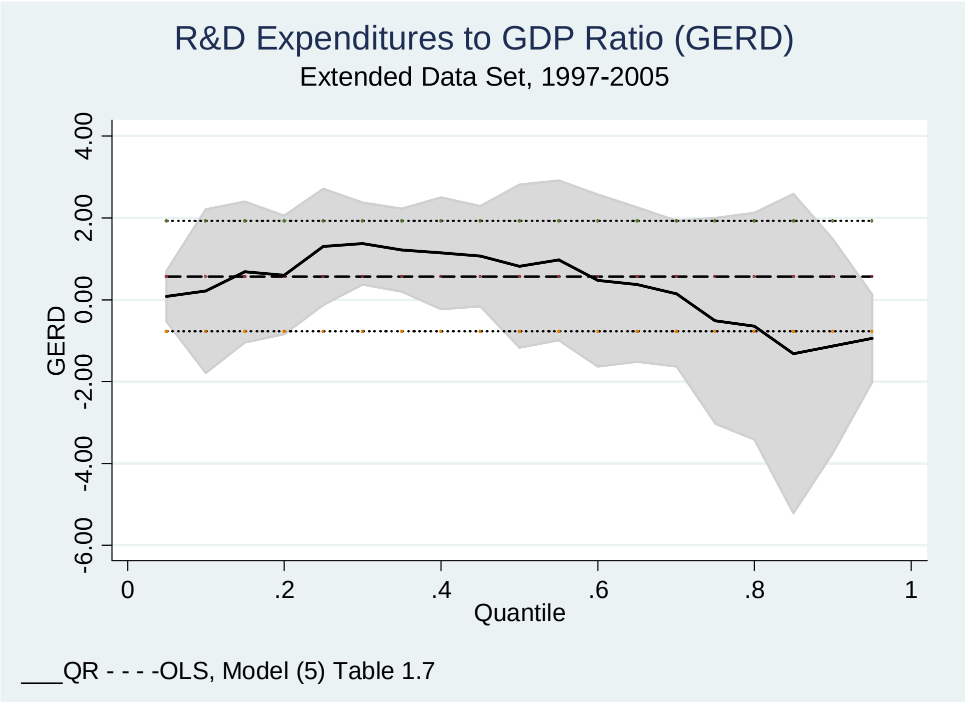
(a)



(b)



(c)



1.6 Conclusion

The cross-sectional analyses of past studies apparently show that there exists a strong and positive relationship between different indicators of financial development (bank-based and market-based) and economic growth. This view remained dominant until the recent crisis that started following the collapse of Lehman Brothers in 2008. The recent literature shows that the strong and positive effect of finance on growth disappears or becomes negative following different episodes of financial crisis, while the relationship remains intact after the crisis are over (see Rousseau and Wachtel, 2011). Further, excess finance may have negative effects on growth (see Arcand et al, 2011; Ductor and Grechyna, 2011).

In this context, cross-sectional analysis may be prone to outliers or omitted variable bias because the indicators of financial development may contain the effects of financial bubbles (see Chinn and Ito, 2006). Hence, being motivated by the recent findings on finance-growth relationship, this chapter primarily investigates whether the finance-growth relationship is affected by outlier observations that are very likely to exist in this kind of analysis. This is explored using datasets from previous studies where the earlier analysis showed a positive relationship between financial development and growth. The secondary aspect of this chapter is to explore whether R&D can play a proxy role of an omitted variable that may have a strong link with economic growth.

For this purpose, we analyse five data sets (four from past studies which are prominent in the literature and one extended data set) using two robust regression methods of median quantile regression (QR) and least trimmed squares (LTS). Overall, the analysis of first four data sets show that the estimated coefficients on almost all the indicators of financial development are positive but sensitive to the presence of outliers except trading value (TVT), finance efficiency (FE), and finance aggregate (FG) which have relatively stable signs and significance. Further, we show that using robust techniques improves the overall fit and our understanding of the finance-growth relationship.

The analysis of our extended data shows that in general the robust effect of PRIV on economic growth is negative and significant. However, the effect of TOR remains negative but insignificant in most of the cases. Our findings of extended data and its results are consistent with a more recent cross-sectional analysis of Rousseau and Wachtel (2011). According to Rousseau and Wachtel (2011) these negative effects of financial development on growth may be explained in the context of repeated financial crises following the financial liberalization of 1990s.

Furthermore, our use of R&D (GERD) as a proxy of an omitted variable plays an important role. Its robust estimates show that it has a strong and positive effect on growth. As the recent literature indicates towards a strong and positive relationship between financial and technological innovation (see Michalopoulos et al, 2010), above finding may help us explore further the interactive effects of financial development and R&D on growth. This observation is needed to be explored using an in-depth time series or panel data analysis because cross-sectional data and its associated issues of heterogeneity, endogeneity and outliers etc. may limit our understanding of the finance-growth relationship. In Chapter 2, we explore this finding further by using a panel data set and more sophisticated econometric techniques.

Appendix A1

Table A1.1: Definitions and Sources of Variables used in the Analysis of Extended Data Set

Variable	Description	Source
Real per capita GDP growth (**GROWTH**)	This variable is used as a measure of economic growth following Beck et. al (2004). It is calculated as the log difference of real per capita GDP.	Author's construction using World Development Indicators (WDI), World Bank
Initial real per capita GDP (**LY0**)	Initial value of real per capita GDP. It is included to take into account the convergence factor.	WDI, World Bank
Human capital (**HC**)	Secondary school enrolment (% of gross)	WDI, World Bank
Private Credit (**PRIV**)	The value of domestic credit to the private sector divided by GDP (%).	WDI, World Bank
Stock market turnover ratio (**TOR**)	Trading value of shares on domestic exchanges divided by total value of listed shares (%).	World Bank database for Financial Development and Structure, 2007.
R&D expenditures (**GERD**)	Gross domestic expenditures on R&D as a percentage of GDP. It is a standard expenditure measure which covers all type of R&D activities carried out on national territory in a given year. It is used as a measure of innovation.	Combined data from WDI, UIS, and OECD-MSTI using the same unit of measurement.
Openness (**OPEN**)	Trade openness: ratio of exports plus imports to GDP ratio.	Penn World Tables 6.2
Government size (**GOV**)	Government consumption: government share of real per capita GDP.	Penn World Tables 6.2
Investment **(INV)**	Investment: gross capital formation to GDP ratio.	WDI, World Bank
Inflation (**INF**)	Inflation: annual percent change in CPI.	WDI, The World Bank

Notes: All variables are used as log transformations except INF. GERD is calculated as log of (1+ gross domestic expenditures on R&D to GDP ratio, %). WDI is used for World Development Indicators. USI is UNESCO Institute for Statistics (UIS). OECD- MSTI is Main Science and Technology Indicators as developed by OECD.

Table A1.2 List of Excluded Outlier Observations in LTS Estimation

Tables 1.1 through 1.7 contain models that exclude outlier observations from their analysis using least trimmed squares (LTS) method. Following is the list of excluded outlier observations from that analysis.

Table 1.1	
Model (3)	Cote d'Ivoire, Korea, Singapore, Venezuela, Zimbabwe
Model (6)	Cote d'Ivoire, Israel, Jamaica, Korea, Nigeria, Philippines, Thailand, Venezuela, Zimbabwe
Model (9)	Cote d'Ivoire, Israel, Korea, Taiwan, Venezuela, Zimbabwe
Table 1.2	
Model (3)	NA
Model (6)	NA
Model (9)	NA
Table 1.3	
Model (3)	Haiti, Korea, Niger, Papua New Guinea, Senegal, Tongo, Zaire
Model (6)	El Salvador, Haiti, Honduras, Japan, Korea, Malta, Niger, Papua New Guinea, Senegal, South Africa, Taiwan, Tongo, Zaire
Model (9)	Haiti, Korea, Niger, Papua New Guinea, Senegal, Tongo, Zaire
Table 1.4	
Model (3)	Cyprus, South Africa, Sri Lanka, Taiwan, Thailand, Trinidad and Tobago
Model (6)	Taiwan, Thailand, Trinidad and Tobago
Model (9)	Cyprus, South Africa, Thailand, Trinidad and Tobago
Model (12)	Cyprus, South Africa, Taiwan, Thailand, Trinidad and Tobago
Table 1.5	
Model (3)	Chile, Cyprus, Ghana, Ireland, Jamaica, Malaysia, Pakistan, Philippines, South Africa, Taiwan, Thailand
Model (6)	Brazil, Chile, Cyprus, Egypt, Ghana, India, Italy, Kenya, New Zealand, South Africa, Spain, Taiwan, Trinidad and Tobago
Model (9)	Chile, Cyprus, Denmark, Finland, Ghana, Kenya, Malaysia, Mexico, Norway, Pakistan, Philippines, Taiwan, Tunisia, United Kingdom, Zimbabwe
Model (12)	Chile, Cyprus, Ghana, Pakistan, Philippines, South Africa, Taiwan, Zimbabwe
Table 1.6	
Model (3)	Jamaica, Korea, Taiwan, Venezuela, South Africa
Table 1.7	
Model (3)	China, Estonia, Latvia, Paraguay
Model (6)	Armenia, Botswana, China, Estonia, Georgia, Ireland, Kazakhstan, Latvia, Lithuania, Macao-China, Trinidad and Tobago
Model (9)	Armenia, China, Jamaica, Kazakhstan, Latvia, Macao-China, Paraguay, Trinidad and Tobago

Table A1.3: First Stage Results of IVQR Estimation in Tables 1.2 and 1.3

First Stage Results						
	Simple Conditioning			Policy Conditioning		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**PRIV**	**LLY**	**CCB**	**PRIV**	**LLY**	**CCB**
LY0	0.251** (0.045)	0.168 (0.198)	0.140* (0.080)	0.173** (0.046)	0.150 (0.141)	0.129** (0.028)
HCBL	0.411* (0.067)	0.191 (0.358)	0.005 (0.975)	0.348** (0.039)	0.160 (0.393)	-0.060 (0.615)
OPEN				-0.074 (0.476)	0.119 (0.332)	0.077* (0.093)
INF				-1.389*** (0.001)	-1.082*** (0.004)	-0.318 (0.366)
GOV				0.251 (0.117)	0.162 (0.303)	0.054 (0.418)
BMP				-0.797*** (0.001)	-0.328 (0.116)	-0.485*** (0.000)
ENGLISH	-0.716*** (0.000)	-0.345** (0.038)	-0.122** (0.032)	-0.525*** (0.003)	-0.290* (0.099)	-0.056 (0.289)
FRENCH	-0.938*** (0.000)	-0.745*** (0.000)	-0.229*** (0.001)	-0.658*** (0.000)	-0.548*** (0.005)	-0.148** (0.017)
SCANDINAVIA	-0.598** (0.013)	-0.566*** (0.001)	-0.140** (0.017)	-0.597** (0.022)	-0.619*** (0.001)	-0.153** (0.027)
Constant	1.664** (0.033)	2.607*** (0.001)	3.414*** (0.000)	2.106** (0.015)	1.983** (0.032)	3.213*** (0.000)
Observations	63	63	63	63	63	63
R-squared	0.585	0.486	0.277	0.780	0.654	0.534

Notes: As for Tables 1.2 and 1.3. ENGLISH is dummy for English origin of law. FRENCH is dummy for French origin of law. SCANDINAVIA is dummy for Scandinavian origin of law. GERMAN, a dummy for German origin of law is dropped due to multicollinearity.

Table A1.4: List of Sample Countries with their Geographic Location

East Asia & Pacific	**Latin America & Caribbean**	**High income: OECD**
China	Argentina	Australia
Indonesia	Bolivia	Austria
Malaysia	Brazil	Belgium
Mongolia	Chile	Canada
Philippines	Colombia	Denmark
Thailand	Costa Rica	Finland
South Asia	Ecuador	France
Bangladesh	Jamaica	Germany
India	Mexico	Greece
Nepal	Panama	Iceland
Pakistan	Paraguay	Ireland
Sri Lanka	Peru	Italy
Europe & Central Asia	Trinidad and Tobago	Japan
Armenia	Uruguay	Korea, Rep.
Bulgaria	Venezuela, RB	Luxembourg
Croatia	**Middle East & North Africa**	Netherlands
Czech Republic	Egypt, Arab Rep.	New Zealand
Estonia	Iran, Islamic Rep.	Norway
Georgia	Jordan	Portugal
Hungary	Morocco	Spain
Kazakhstan	Tunisia	Sweden
Kyrgyz Republic	**Sub-Saharan Africa**	Switzerland
Latvia	Botswana	United Kingdom
Lithuania	Mauritius	United States
Macedonia, FYR	South Africa	**High income: non-OECD**
Moldova	Uganda	Cyprus
Poland	Zambia	Hong Kong, Chi
Romania		Israel
Russian Federation		Kuwait
Slovak Republic		Macao, Chi
Turkey		Malta
Ukraine		Slovenia

Table A1.5: Summary Statistics and Correlations

Variable	N	Mean	Median	SD	Min	Max
GROWTH	86	2.8859	2.3959	1.9617	-0.7810	9.1500
LY0	86	8.2676	8.2103	1.4454	5.3525	10.5560
HC	86	4.4269	4.4930	0.3486	2.8081	5.0266
INV	86	3.1017	3.0978	0.1922	2.6267	3.6822
PRIV	86	3.8121	3.8244	0.8859	1.6298	5.2924
TOR	86	3.2554	3.5024	1.3670	-0.1726	5.9083
GERD	86	0.5744	0.4828	0.4053	0.0154	1.6775
PRIV*GERD	86	2.3830	1.7587	2.0131	0.0310	7.4909
TOR*GERD	86	2.1121	1.2920	1.9420	-0.0416	7.1980

Notes: Measure of Innovation is government expenditures on R&D to GDP ratio (GERD). Measures of financial development are private credit to GDP ratio (PRIV) and turnover ratio (TOR). The data used is annual averages for 86 countries over the period 1997-2005. All variables are in natural log form.

Correlations

	GROWTH	LY0	HC	INV	PRIV	TOR	GERD	PRIV* GERD	TOR*GERD
GROWTH	1.000								
LY0	-0.236	1.000							
HC	0.097	0.670	1.000						
INV	0.386	-0.150	-0.049	1.000					
PRIV	-0.272	0.738	0.454	-0.018	1.000				
TOR	-0.046	0.301	0.298	0.041	0.330	1.000			
GERD	-0.098	0.644	0.442	-0.011	0.544	0.442	1.000		
PRIV*GERD	-0.160	0.716	0.471	-0.025	0.669	0.456	0.977	1.000	
TOR*GERD	-0.122	0.633	0.468	-0.006	0.557	0.653	0.936	0.939	1.000

Chapter 2

A Panel Data Analysis of the Role of R&D for the Effect of Financial Development on Growth

2.1. Introduction

Before the start of the world financial crisis, which might be dated from the collapse of Lehman Brothers in September 2008, the dominant view in the finance-growth literature was that more financial development results in higher levels of economic growth, mainly through its impact on productivity growth (see King and Levine, 1993a, 1993b; Levine, 1997; Beck et al, 2000a; Benhabib and Spiegel, 2000; Aghion et al, 2005; Ang, 2008). Further, it was largely accepted that high levels of financial development reflect sound policies and institutions. Recent evidence alters our thinking by showing that countries at the heart of the financial crisis may have financial systems that are "too large" and these exist not because of good policies and institutions, rather because of poor regulatory systems (see Arcand et al, 2011). Consequently, some current literature argues that excessive financial development is an amplifying factor behind the financial crisis and negative growth (see Arcand et al, 2011; Ductor and Grechyna, 2011).

A reason there may be "too much finance" is due to technical change because a successful innovation can require new financial arrangements that may suit the financing of risky innovative projects (see Michalopoulos et al, 2010). Hence, financial intermediaries compete in financial innovations that may be in the form of new financial instruments, new corporate structures, the formation of new financial institutions, or developing new accounting and reporting techniques or methods (see Michalopoulos et al, 2010). Consequently, financial innovations alter the nature of transactions in the financial sector by expanding its operations beyond the typical domain; thus exposing it to higher risk that may result in a crisis and leaving a negative impact on growth (see Rajan, 2005; Palmerio, 2009).

The discussion above may imply that technological innovation or R&D activities that are financed by the financial sector may affect the relationship between financial sector development and economic growth due to the riskiness in their outcomes. This is due to the fact that any research endeavour does not necessarily have to have successful outcomes (see Hall and Lerner, 2009; Ilyina and Samaniego, 2011). Another implication may be that in meeting the demand for financing new innovative projects, financial institutions and markets go beyond their limits in extending loans to the private sector by introducing new financial products which are complex in nature. Consequently, financial growth leaves behind industrial growth which results in excess finance, in the presence of which financial development may have a negative impact on economic growth both in the short and long run (see Ductor and Grechyna, 2011). Further, empirical evidence shows that in the short run when the difference between financial and industrial growth exceeds 4.45% the effect of financial development on economic growth becomes negative or it may result in a severe financial crisis (see Ductor and Grechyna, 2011). It may also suggest that as an economy approaches its production capacity, adding more financial development may have a weaker or vanishing effect on growth which may become negative after the production capacity is reached (see Aghion et al, 2005; Ductor and Grechyna, 2011). In this context it is important to investigate the growth effect of financial development as the level of technological innovation or R&D changes.

There are numerous theoretical and empirical studies which show a positive and significant relationship between R&D and economic growth, particularly expenditures on industrial R&D are considered as one of the most important determinants of total factor productivity and thus output growth (see Aghion and Howitt, 1992; Nadiri, 1993; Aghion and Howitt, 1998; Falk, 2007; Coe and Helpman, 1995; Coe et al, 2008). On the other hand, a substantial volume of research has been devoted to verify and understand the existence and nature of linkages between financial development and economic growth using bank-based or market-based (or both) measures of financial development. Although, until recently, the accepted view was that there exists a positive and strong relationship between financial sector development and economic growth, there are exceptions (see King and Levine, 1993a; Arestis and Demetriades, 1997; Levine and Zervos, 1998; Beck and Levine 2004; Rioja and Valve, 2004; Ang, 2008).

Recent literature on financial development and growth brings into picture the effects of technological innovation, financial liberalization policies and crisis that may alter our understanding of the finance-growth relationship (Michalopoulos et al, 2010; Ang, 2010, 2011; Arcand et al, 2011; Ductor and Grechyna, 2011; Rousseau and Wachtel, 2011). This literature suggests that technological innovation is important for economic growth as well as it has a strong positive link with financial innovation which is evident from a very high correlation coefficient (around 99%) between the productivity growth of financial and manufacturing sectors (see Michalopoulos et al, 2010). In this context, technological innovation may proxy the role of other variables. In particular, if countries with a high level of technological innovation also have less close financial regulation, then the apparent role of technological innovation will be quite complex. As evident from the recent financial crisis, unregulated or unmonitored financial innovation may result in excess finance which is very likely to cause financial crisis thus leaving an adverse effect on economic growth. Most available studies either split their sample over different time periods to show the effects of financial crises or use nonlinear methods to identify the optimal level of financial development beyond which its effect on growth changes (see Rousseau and Wachtel, 2011; Arcand et al, 2011; Ductor and Grechyna, 2011).

Being motivated by the above discussion, in this chapter we contribute to the finance-growth literature by using a measure of technological innovation or R&D that may show important interactive effects (with financial development) on growth. Hence, besides looking at the direct effects of financial development and R&D on growth, we address two important questions: whether the growth effect of financial development is conditional on the level of innovation or R&D; and whether a high level of technological innovation or R&D is associated with an apparently weak or negative effect of financial development on growth. We investigate these questions by employing a multiplicative interaction model, where the interactive effect of technological innovation and financial development on economic growth is analysed. We use a panel data of 36 countries (26 OECD and 10 non-OECD) over the period 1980-2006 to explore this conditional effect by employing a variety of panel data techniques.

The structure of our study is as follows: Section 2.2 reviews the key elements of the literature related to finance, innovation and growth. Section 2.3 then discusses the data and econometric methods used in this study. Section 2.4 explains the results, while concluding remarks are provided in Section 2.5.

2.2. Literature Review

In the following subsections we review some of the important empirical studies related to finance, innovation and growth.

2.2.1. Financial Development and Economic Growth

Current debate on the finance-growth relationship has taken a new turn by taking into account the roles of technological innovation, financial innovation, financial liberalization and financial crises. This literature shows that the effect of financial development on growth is not always positive and significant, as predicted by most past studies. It conjectures that technological innovation leads to the development of new financial products as every technological innovation renders existing financial regulations and practices obsolete (see Michalopolous et al, 2010). These financial innovations are extremely complex and the relatively outdated financial regulations and practices impede our ability to recognize financial crises in advance (see Ang, 2011). Therefore, excessive financial development or financial innovation may increase the probability of a financial crisis and weaken the effect of financial development on growth (see Arcand et al, 2011; Ductor and Grechyna, 2011; Rousseau and Wachtel, 2011).

Starting from the pioneer work of Schumpeter (1934), economists hold different views regarding the relationship between financial development and economic growth. Schumpeter (1934) argues that well functioning banks spur innovation in technology and products by channelizing funds to their most productive use (see Levine, 1997). Contrary to this view, Robinson (1952) finds that "where enterprise leads finance follows". This statement goes in favour of the demand following nature of finance, where economic development creates a need for well developed financial institutions and markets to grow. There are also other studies who claim that economists may overemphasize the role of finance in economic growth (see Lucas, 1988; Rodrick and Subramanian, 2009).

Following the theoretical debates, Goldsmith (1969) provides the pioneer empirical work on the relationship between economic growth and aggregate measures of the financial system, using data for 35 countries over the period 1860-1963. He suggests an overall positive relationship between financial development and economic growth subject to the data spanned over several decades. Further, he finds that few countries witnessed more rapid growth accompanied by an above average rate of financial development.

After Goldsmith (1969), the focus of discussion was on financial repression, namely a policy adopted by governments to lower interest rates (artificially) and increase inflation in order to boost revenues and economic growth. These policies are based on the theoretical work of Keynes (1936) and Tobin (1965), who advocate government intervention in capital markets. McKinnon (1973) and Shaw (1973) coincidentally raise arguments against the policies of financial repression. They emphasize the role of financial institutions and markets in mobilizing savings to their most productive use, which can be achieved by abolishing interest rate ceilings and replacing seigniorage through inflationary monetary policies. An important feature of their models is that they explain only temporarily higher growth rates. However, the effect of their policies adopted by many developing countries is mixed (see Eschenbach, 2004).

For example, real interest rates increased to very high levels in Chile during the 1976-1982 reforms, which caused severe adverse selection among non-bank borrowers as well as moral hazard among the banks themselves. Consequently, the lack of bank supervision caused a financial crash (see Diaz-Alejandro, 1985; McKinnon, 1989). On the other hand, Korea coupled a price stabilization programme with management of interest rates. Thus, in the presence of maintained capital account restrictions and appropriate exchange rate policies, scaling down nominal interest rates during periods of disinflation prevented the country from excessive foreign capital inflows and saved it from massive international indebtedness (see McKinnon, 1989; Eschenbach, 2004). Hence, stable macroeconomic conditions and sound banking regulations may play important roles in the success of financial liberalization policies (Eschenbach, 2004; Ang, 2010).

Henry (2000) uses panel data for 11 developing countries to examine whether stock market liberalization causes investment booms. His results show that stock market liberalization leads to increased investment in 9 out of 11 countries and that the average growth rate of private investment is 22 percent points higher than the sample average three years after the liberalization. His conclusion is contrary to the view that capital account liberalization has no effect on investment.

Similarly, empirical evidence on the effects of financial repression is also mixed across countries. Demetriades et al (1998) investigate the impact of financial repression policies of interest rate controls, directed credit programs and reserve and liquidity requirements on the average productivity of capital in five South East Asian economies (India, Philippines, South Korea, Sri Lanka and Thailand) . They find that the direct effects of financial repression on average productivity of capital are negative and significant in most of these cases with an exception of South Korea, for which the effect is positive and significant. South Korea may be a case where these policies successfully explain market imperfections and direct resources to their social optimum. Their results are consistent with the market imperfection approach, where market failures in the form of asymmetric information and moral hazard may suggest that financial repression can cause shifts in the average productivity of capital through regime switches, perhaps by changing the degree of public confidence in the banking system.

A new strand of literature emerged in the 1990s seeking evidence in favour of endogenous growth theory with a central argument that finance reduces informational frictions and generates an external effect on aggregate investment efficiency which in turn offsets the notion of decreasing marginal productivity of capital (Greenwood and Jovanovic, 1990; Bencivenga and Smith (1991); Eschenbach, 2004). For example, Greenwood and Jovanovic (1990) develop a theoretical model that combines two prominent strands of growth and development literature: first, a relationship between growth and distribution of income; second, a link between growth and financial sector development. In their model financial intermediation and growth are endogenously determined and there exists bi-causality between them. That is, growth facilitates costly financial structures which in turn make efficient use of investments by allocating resources to their most productive use and protecting investors against idiosyncratic risk. Bencivenga and Smith (1991) present a model where financial intermediaries channel savings to more productive activities by allowing investors to hold two types of assets: first, liquid assets which are risk free and unproductive; second, illiquid assets which are highly productive and risky. Contrary to the uncertainty of individuals regarding their future liquidity needs, banks face predictable demand for liquidity from their depositors thus reducing the individuals' liquidity risk. Consequently, banks are enabled to provide liquidity and allocate investment funds more efficiently.

A seminal contribution in this context is the empirical work of King and Levine (1993a) who use cross-sectional data for 80 countries over the period 1960-1989 to investigate whether higher levels of financial development are significantly and robustly correlated with faster current and future rates of economic growth, physical capital accumulation, and improvement in economic efficiency. Their results are consistent with the Schumpeterian view that finance is important to economic growth and it stimulates economic growth through increasing the rate of capital accumulation and the efficiency with which capital is used.

The theoretical and empirical studies in this context try to establish either the importance of finance to economic growth or the channels of transmission from financial development to economic growth. Although these studies generally suggest a strong positive relationship between financial development and economic growth, there are exceptions. Further, most of the empirical literature is based on bank-based measures of financial development and uses cross-sectional analyses rather than in-depth time series or panel data analyses (see Gregorio and Guidotti, 1995; Demetriades and Hussein, 1996; Levine, 1997; Arestis and Demetriades, 1997; Ang, 2008).

The debate related to financial structure, whether banks or stock markets are important to economic growth, still continues. With some exceptions, most of the literature however supports the financial services view that both the banks and stock markets are important to economic growth (see Arestis and Demetriades, 1997; Rousseau and Wachtel, 2000; Beck et al, 2000b; Beck and Levine, 2002; Beck and Levine, 2004; Ndikumana, 2005). Theoretical and empirical evidence provides mixed observations on the relationship between stock market development and economic growth. On the one hand, a group of studies find a positive and strong relationship between indicators of stock market development and economic growth (see Levine and Zervos, 1996; Mauro, 2003; Blackburn et al, 2005). On the other hand, another group find a weak or no effect of stock market development on growth (see Stiglitz, 1985; Singh, 1997; Arestis et al, 2001).

For example, Singh (1997) investigates the role of the stock markets in the liberalisation process of developing countries during 1980-1990s and explores their corresponding effects on industrialization and economic growth. He concludes that, in general, financial liberalization and the associated expansion of stock markets in developing countries are unlikely to help in achieving their goals of quicker industrialization and faster long-term growth. This may be due to inherent price-volatility as a weak guide for the efficient allocation of investment, macroeconomic instability due to interactions of stock and currency markets in the presence of unfavourable economic shocks, and undermining the group-banking systems which despite many difficulties are still beneficial in many developing countries.

Arestis et al (2001) argue that stock markets provide less risky and easy access to capital markets which improves the allocation of capital, an important channel of economic growth. However, the increased liquidity provided by stock markets may be harmful for economic growth because: it increases the returns to investment which results in decreased saving rates; it decreases uncertainty which results in decreased precautionary demand for savings; and dissatisfied participants in the market may sell quickly which may result in a negative impact on corporate governance. The other important characteristic is price volatility which may undermine the ability of stock markets to promote an efficient allocation of investment. However, a certain level of price volatility is clearly desirable since it may reflect the effects of new information flows in an efficient stock market.

Time series studies attempt to resolve the issue of causality and come to mixed conclusions. They imply that causality results are country specific and cannot be generalized, thus indicating the potential danger of combining different countries with different institutional characteristics and background. Further, they indicate that the nature of the causal relationship is long run because there is no evidence of short run causality, there are exceptions (see Demetriades and Hussein, 1996; Arestis and Demetriades, 1997; Calderon and Liu, 2003; Christopoulos and Tsionas, 2004; Shan and Jianhong, 2006; Kar et al, 2011; Bangake and Eggoh, 2011; Hassan et al, 2011).

In studying the relationship between financial development and economic growth we cannot ignore the income and regional factors that may alter the nature of this relationship. For example, Gregorio and Guidotti (1995) and Odedokun (1996) document that there is a strong and positive relationship between financial development and economic growth in low income as compared to high income countries, although the results are sensitive to data sets. Gregorio and Guidotti (1995), in the same study, show that there exists a strong negative relationship between financial development and economic growth in Latin American countries that might be due to subsequent failures of unregulated financial liberalization and government bailouts during 1970s and 1980s. On the other hand, Naceur and Ghazouani (2007) observe that financial development is unimportant or even harmful for economic growth in the MENA region, which might be due to underdeveloped financial systems in the region that hinder economic growth or unstable growth rates that may affect the quality of finance-growth nexus. Similarly, Demetriades and James (2011) find no overall effect of finance on growth in Sub-Saharan Africa that may be due to the dysfunctional nature of credit markets in these countries.

Recent research indicates that there may exist a non-linear relationship between financial development and economic growth. For example, Rioja and Valve (2004) find that the relationship between financial development and growth varies across the level of financial development. They use a group of 74 countries, where the data is divided into three regions according to the level of financial development: low, middle, and high. They observe positive and significant effects of financial development on growth in middle and high regions, the former being larger in size. However, they find ambiguous results in low regions. Deidda and Fattouh (2002) show that a positive and significant relationship between the level of financial depth and growth holds only for countries with higher per capita income, whereas no such relationship exists for a low income group. However, some other studies employ different parametric and non-parametric techniques to investigate the non-linearity in finance-growth relationship and find inconclusive results (see Stengos and Liang, 2005; Ketteni et al, 2007). Recently, Yilmazkuday (2011) finds threshold levels of inflation, government size, openness and income above and below which the finance-growth relationship changes.

Similarly, there are other studies who attempt to explore the channels of productivity growth, physical capital accumulation, human capital accumulation, and inflation. These studies document that the main channel through which financial development affects economic growth is productivity growth rather than capital accumulation (see Beck et al, 2000a; Benhabib and Spiegel, 2000; Calderon and Liu, 2003). Benhabib and Spiegel (2000) also observe the positive and significant relationships between the indicators of financial development and physical and human capital accumulation, their results being sensitive to the inclusion of country specific fixed effects and different measures of financial development. On the other hand, it is observed that the strong and positive relationship between financial development and growth is associated with disinflations (see Rousseau and Wachtel, 2002).

Recognizing the importance of institutional factors, many studies incorporate the effects of overall legal environment and financial regulations in the discussion of finance-growth relationship (see Levine et al, 2000; Beck et al, 2000b; Beck and Levine, 2002). Their findings support the view that improved legal and accounting standards can enhance the performance of financial sector, thus promoting economic growth. Further, they show that industries which depend more on external finance are likely to grow faster in countries with more advanced financial systems and more efficient legal systems.

Cole et al (2008) extend the existing finance-growth literature by examining whether bank stock returns contain information about future economic growth that is independent from the information contained by overall market returns. This is the first study which provides evidence of a positive and significant relationship between bank stock returns and future economic growth that is independent of the relationship between overall market stock returns and growth, using a sample of 18 developed and 18 emerging markets. They note that much of the predictive power of bank stock returns is captured by country-specific and institutional characteristics, like banking crises and the enforcement of insider trading law.

A new wave of literature is emerging after the collapse of Lehman Brothers in September, 2008 that incorporates the effect of financial crises in studying the finance-growth relationship. For example, Rousseau and Wachtel (2011) observe a positive and strong relationship between financial deepening and growth over the period 1960-1989, whereas a weak and even negative relationship is observed for more recent data (1990-2004). They argue that financial deepening has a positive effect on economic growth only if it is not done excessively otherwise it results in credit booms that may weaken the overall banking system and increase inflation even in the developed countries, thus leading to a financial crisis. Further, they observe that the finance-growth relationship remains intact once the crisis is over. They argue that the weak relationship in recent years (1990-2004) may be the result of repeated financial crises during these years. Therefore, they stress financial development which is accompanied by appropriate policies for financial sector reforms and regulations.

Another important study is Arcand et al (2011) which shows that there exists a threshold level of private credit (estimated as 110% of GDP) below which the effect of financial development on growth is positive, whereas it is negative above it. This non-monotonic relationship between financial development and economic growth is consistent with their hypothesis that there can be "too much" finance. They view their results in the light of the recent financial crisis that raises concerns about financial systems which are larger than the size of domestic economies and show that all the advanced economies that are facing problems are located above their "too much" finance threshold. They note that finance size plays an important role in amplifying the effects of the global recession that followed the collapse of Lehman Brothers in September 2008. Almost similar conclusions are found by Ductor and Grechyna (2011).

Overall, the above studies indicate that there is no definitive answer to the question whether there exists a strong and positive relationship between financial development and growth. Empirical evidence indicates that the nature of this relationship varies across a number of factors like income groups, regions, stages of development, measures of financial development, finance size, financial liberalization policies, financial crisis, and econometric techniques etc. However, there is still a need to explore the precise conditions and channels that may explain the nature of relationship between financial development and economic growth.

2.2.2. The Role of Technological Innovation

A strand of current literature emphasizes the importance of technological innovation in understanding the finance-growth nexus (see Michalopoulos, 2010; Pienknagura, 2010; Ang, 2010; Ang, 2011; Ilyina, 2011; Zagorchev et al, 2011). For a clearer picture we need to combine two important strands of endogenous growth literature, finance-growth (explained above) and innovation-growth. The recent theoretical models of endogenous growth theory recognize capital accumulation and innovation as joint determinants of growth (see Aghion and Howitt, 1992; Howitt and Aghion, 1998). These models show that any subsidy to capital accumulation, whether physical or human, leaves permanent effects on the economic growth rate. Consequently, they recognize capital as an input to R&D because R&D contains a great deal of physical capital in the form of laboratories, offices, plants, computers and other scientific instruments etc. They suggest that a broad subsidy to capital accumulation may be as effective as a direct subsidy to R&D in order to spur technological progress and economic growth. Such a subsidy will work by raising the reward to innovations that need capital for their production and implementation. They conclude that their model of Schumpeterian growth theory is more consistent with the evidence that investment is empirically an important determinant of economic growth.

Empirical evidence by Nadiri (1993), Falk (2007), Coe and Helpman (1995) and Coe et al (2008) are consistent with Howitt and Aghion (1998). These studies show that the effects of industrial R&D expenditures are larger and positive on economic growth, especially on total factor productivity, as compared to public R&D. Further, not only the level but the composition of R&D is also important to economic growth and productivity. To assess whether the composition of R&D in OECD countries has shifted from low-tech to high-tech sectors, Falk (2007) investigates the impact of investment in business R&D and its composition and share of R&D performed in the high-tech sector on economic growth using a panel of 19 OECD countries. He concludes that both business enterprise expenditures on R&D and its component have positive and significant impacts on growth. He further concludes that an increase of 10% in the share of R&D in high-tech sector leads to 0.26% increase in real per capita GDP growth.

Overall, these theoretical and empirical studies suggest a positive and significant relationship between innovation or R&D and growth. Very little effort has been made to combine the above two strands of literature: finance-growth and R&D-growth. Current studies on finance and innovation relationship may help us bridge this gap.

The relationship between finance and innovation can be traced back to Schumpeter's (1934) economic analysis of innovation in which the allocation of financial resources plays a central role. However, over time there was a dramatic change in his ideas related to the characterization of innovation process and its financing. In his early writings[19], he emphasized the importance of the financial system, especially commercial banks, for facilitating innovation activity that he regarded as the motive force behind the economic development of any country. On

[19] Theory of Economic Development (1934), Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process (1964)

the other hand, in his later book[20], he de-emphasized the role of credit creation in facilitating innovation and economic development, thus emphasizing the self-financing of innovative investment by dominant enterprises. This shift in his ideas is attributed mainly to the well-known transformation in his characterization of innovation from a process driven by new, entrepreneurial ventures to one dominated by large-scale industrial enterprises, where the former is financed through credit creation by commercial banks, while the latter is self-financed by large scale enterprises. Schumpeter's revised characterization of innovation processes led him to de-emphasize the role of external finance and banking system in favour of internal financing.

Most contemporary economists of innovation focus their attention on Schumpeter's characterization of innovation and argue that both of these patterns of innovation coexist in the economy, with some industries characterised by first-type and others by second-type innovation (see O'Sullivan 2004, Winter 1984). However, they generally overlook the relationship between finance and innovation.

A significant theoretical contribution by Saint-Paul (1992) is to introduce the impact of financial markets on technological choice. In his model, agents can choose between two technologies, highly flexible and highly rigid or specialized. The highly flexible technology is lesser productive technology is preferred in the absence of well developed financial markets, while the specialized one is more productive and is preferred when financial markets are well developed. As economic shocks may change consumers' preferences regarding some products, the absence of well developed financial markets may lead risk-averse consumers to prefer flexible rather than specialized technology. However, the presence of financial markets provides them with an opportunity to diversify their investment portfolio which insures them against any negative demand shock while keeping more productive technologies.

Another important contribution in this regard is King and Levine (1993b) who argue that financial systems influence decision to invest in productivity enhancing activities through two mechanisms, evaluating prospective entrepreneurs and funding the most promising ones. These mechanisms lower the cost of investing in productivity enhancing innovative activities and stimulate economic growth. They argue that better financial services expand the scope and improve the efficiency of

[20] Capitalism, Socialism, and Democracy (1942)

innovative activity thus accelerating economic growth, whereas financial distortions can decrease the rate of economic growth. A central element of their theoretical model is external financing of innovative activity for two reasons: first, the labour requirements of innovation are much larger than the entrepreneur time and the entrepreneur's wealth is insufficient to pay for labour; second, undertaking innovative projects is very risky, and its risk is entirely diversifiable, so that reliance on internal finance is inefficient.

Empirically, they test their theoretical predictions using cross-sectional data for 77 countries over the period 1960-1989. The results support their theoretical findings, that is, better financial systems stimulate economic growth and productivity-enhancing activities. Further, their firm level case studies show that changes in financial sector policies are predictably associated with changes in aggregate measures of financial development. They show that financial liberalization redirects the allocation of credit to the most efficient firms. However, financial liberalization combined with explicit or implicit official deposit guarantees and insufficient supervision leads to financial crises, as happened in Argentina, Chile, and Philippine.

In their seminal study, Rajan and Zingales (1998) introduce a new channel by which the financial development can affect growth via firms' dependence on external finance, by disproportionately helping those firms which are more dependent on external finance for their growth. They use industry level as well as macro level annual data on 30 countries and show that the effect of financial development on the rate of economic growth is positive and significant through the channel of reducing the cost of external finance to financially dependent firms. Further, they provide evidence of a significant and positive impact of the interaction between an industry's dependence on external finance and the accounting standards of the country in which it operates on industry value added. Almost similar results are shown by Pienknagura (2010) and Ilyina and Samaniego (2011).

A similar analysis is undertaken by Sharma (2007) who uses firm level data for 57 countries collected from World Bank Enterprise Surveys, carried out between 2003 and 2006, to examine how financial development affects innovation in small firms. His findings are as follow: First, within industries, small firms relative to large firms are more likely to carry out R&D in countries at higher levels of financial development. Second, within R&D firms, small firms report more innovation per unit of R&D than large firms, the gap being narrower in countries at higher levels of financial development. Third, the relationship between financial development and innovation by small firms relative to large firms is stronger in industries more dependent on external finance. Finally, relative R&D by small firms is significantly related to bank-based rather than market-based financial development.

Addressing the issue of moral hazard in the research or innovation sector, Morales (2003) is the first to explicitly model the conceptual relationship between the researcher and the provider of funds in a model of endogenous technological change in line with Howitt and Aghion (1998). She argues that research productivity is determined in the credit market and may be affected by financial variables because financial intermediaries use their monitoring power to force researchers to exert a higher level of effort. Hence any subsidy given to the financial sector may enhance R&D activity, thus heading the economy to a faster balanced growth path. She argues that a subsidy given to the financial sector may be more effective than a direct subsidy to research. That is, a direct subsidy to research may cause higher research intensity that enhances the growth rate but any change in tax is likely to reduce the researchers' incentive to exert a higher level of effort. Consequently, there will be higher monitoring costs and lower R&D productivity. Hence, given a higher subsidy rate to research, the growth effect can become negative due to moral hazard. Her finding also implies that financial sector development and innovation are substitutes in promoting economic growth.

Aghion et al (2005) develop and test a Schumpeterian model of cross-country convergence with financial constraints. They conjecture that all countries above some critical level of financial development converge to the growth rate of the world technology frontier, whereas all other countries have strictly lower long-run growth. In these converging countries the effect of financial development on steady state growth is positive but vanishing. In order to test the above implication of their model they estimate a cross country growth regression with an interaction term between financial development and initial per capita GDP and find that it is negative, significant and robust. This negative sign shows that in the presence of low level of financial development the convergence is less likely. They also show that productivity growth is the main channel through which financial development affects growth, rather than capital accumulation. They make two conclusions: first, the probability that a country will converge to the frontier growth rate increases with its level of financial development; second, in a country that converges to the frontier growth rate, financial development has a positive but vanishing effect on the steady state growth.

Literature shows that financial development also helps in solving the agency problem which otherwise may limit the innovators' access to external finance (Aghion et al, 2005; Kim, 2007). An innovator can deceive her creditors by hiding the results of a successful innovation at a cost which is positively related to the level of financial development. Hence, when financial development is low there is an incentive for an innovator to hide the results of a successful innovation due to the low cost of defraud or deceiving. Kim (2007) hypothesizes that a well developed financial sector reduces the agency costs which enable a larger flow of funds towards the research sector, thus increasing the rate of technological innovation. To test his theoretical hypothesis, he uses panel data for 27 developing countries and concludes that a well developed financial sector is a significant determinant of patent growth rates in these countries, with the latter being the engine of growth.

Recognizing the importance of financial liberalization in finance-growth analysis, Ang (2011) focuses on the channel of knowledge accumulation through which financial development and financial liberalization may affect economic growth. He uses panel data for 44 OECD and non-OECD countries to show that financial deepening has a positive and significant impact on knowledge accumulation in advanced as well as developing economies, whereas financial liberalization policies have a negative impact on knowledge accumulation in developing countries. This negative effect of financial liberalization may be due to financial crises and volatility. Further, financial liberalization may reallocate talent from innovation to the financial sector as the latter offers relatively high returns. His views are consistent with the view that financial development reduces monitoring costs and moral hazard problems which results in innovative production (see Blackburn and Hung, 1998; Aghion et al, 2005).

Michalopoulos et al (2010) shows that technological innovation and financial innovation go hand in hand, where the former increases the returns to financial innovation. That is, improved screening methodology generates monopoly rents for a financier, as for a successful innovator. However, it is observed that given a technological innovation every existing screening methodology becomes obsolete in identifying the promising entrepreneurs, thus driving financiers to invent and develop specialized investment banks, new contracts, and more detailed reporting standards for better monitoring and evaluation of high-tech firms. Therefore, economic growth eventually stagnates in the absence of financial innovation, irrespective of the initial level of financial development. Their empirical results show that a faster rate of financial innovation accelerates the rate at which an economy converges to the growth rate of the technological leader. Further, their results are consistent with the view that innovations in the real and financial sectors are strongly and positively correlated.

Overall, this literature suggests that financial sector development plays an important role in promoting productivity enhancing innovation activities which is the major determinant of growth. Further, it suggests that moral hazards and financial liberalization policies may be harmful for the accumulation of knowledge or R&D activities which may negatively affect economic growth. Moreover, this literature points towards an important factor of financial innovation that may be a result of technological innovation.

2.2.3. Building Testable Hypotheses

The above discussion suggests that financial development may affect economic growth through its impact on technological innovation. The very high positive correlation (around 99%) between the productivity growth of financial and manufacturing sectors (see Michalopoulos et al, 2010) suggests that R&D variables may proxy a range of financial indicators that are difficult to observe. In particular, the relationship between financial development and economic growth is vulnerable to the outcomes of unregulated and unmonitored financial liberalization policies that may be in the form of excessive finance, extremely complex financial innovations and crisis (see Arcand et al, 2011; Michalopoulos et al, 2010; Rousseau and Wachtel, 2011). Evidence shows that after every technological innovation the existing financial regulations and practices become obsolete hence financial intermediaries compete in designing and offering new financial products and contracts to meet the demands of innovators (see Pamerio, 2009; Gennaioli et al, 2010). In doing so, financial intermediaries are excessively involved in the sale and purchase of securities, rather than issuing loans to promising entrepreneurs. The last two decades witness a big shift in regulation (regulatory and tax codes etc.), for example, allowing non-bank entities to operate in markets where previously only banks were allowed to operate. At the same time, banks have been allowed to extend their operation to capital markets, besides the usual supply of loans to entrepreneurs (see Rajan, 2005; Palmerio, 2009).

Therefore, financial intermediaries are exposed to excessive risk by transferring their assets to other specialized operators, who in turn issue liabilities that are purchased by institutional investors who then transform and sell them to the final buyers (see Palmerio, 2009). The transfer of risk to other agents weakens the bank's incentive to rigorously select and monitor its clients. Further, financial innovations facilitate the extraction of short term profits for financiers rather than improving their screening methodologies. For example, securitization being an important financial innovation is seen to reduce lending standards and increase the loan-default rates, while boosting the supply of loans and financier profits (see Dell'Ariccia, 2008; Michalopoulos et al, 2010). Hence, financial innovations which are not properly regulated and monitored may lead to: deterioration of credit standards; growth of non-performing loans; credit booms and bank crisis (see Gennaioli et al, 2010; Michalopoulos et al, 2010; Rousseau and Wachtel, 2011). Consequently, in the wake of financial crisis the effect of financial development on growth either becomes weak or negative (see Rousseau and Wachtel, 2011).

The above discussion suggests an important interaction between financial and innovation sectors that may play an important role in understanding the nature of finance-growth relationship. It further suggests that the effect of financial development on growth may not be straight-forward rather it may be conditional on the level of technological innovation, which in turn may proxy other (missing) variables and specifically the regulation of new financial instruments. In this context, it is worthwhile to study the interactive effect of financial development and technological innovation on growth, rather than focusing on their direct effects. For this purpose we use a measure of innovation or R&D (GERD) together with its interactions with financial development in order to study economic growth. This kind of analysis may help us to understand how the growth effect of financial development changes as the level of technological innovation changes. Thus, in this chapter we investigate the interactive effects of financial development and technological innovation or R&D on economic growth by using a multiplicative interactive model. Further, as implied by the above discussion we expect a negative sign on the coefficient of our interaction term which suggests that as innovation increases the growth effect of financial development decreases. A negative interactive effect also suggests that financial development and innovation are substitutes in promoting economic growth.

Hence, on the basis of above discussion we establish our testable hypotheses of research as:

H1- The relationship between financial development and economic growth is conditional upon the level of technological innovation or R&D.

H2- A high level of technological innovation or R&D is associated with a weak or negative effect of financial development on economic growth, since technological innovation proxies the effects of complex financial innovations that are poorly regulated.

We test above hypotheses using a multiplicative interaction model as suggested by Friedrich (1982), Aiken and West (1991), and Brambor et al (2006) which is estimated by Two-way Fixed Effects, Difference GMM, and system GMM estimators.

2.3. Data and Methodology

2.3.1. Data

Our dynamic panel analysis consists of five year averages of 36 countries (26 OECD and 10 non-OECD)[21] for the period 1980-2006[22]. Therefore, we have period averages for t = 1, 2, …, 5. We use five year averages to control for business cycle effects. Due to data limitations, the selection of countries and time period is purely based on the availability of annual observations on R&D variables: R&D intensity (BERDIND) and number of patent applications (NPATA). We use real per capita GDP growth (GROWTH) as the measure of economic growth. The initial value of real per capita GDP (LY0) is included to control for convergence, whereas average

[21] List of countries is given in the Appendix A2, Table A2.1.

[22] Five year averages are calculated over the period 1981-2006: 1981-1985, 1986-1990, 1991-1995, 1996-2000, and 2001-2006. The observation of 1980 is used as a proxy of initial per capita real GDP (LY0) for first average over the period 1981-1986. Although we mention five year averages, the last average is based on six years which is only due to the availability of data.

years of schooling (HCBL) and investment share of GDP (INV) are included to allow for conditional convergence[23] (see Barro, 1991; Mankiw et al, 1992; Gittleman and Wolff, 1995). LY0 is found to be highly significant in a wide range of specifications in empirical growth literature (Gittleman and Wolff, 1995). Similarly, the positive growth effect of INV is found to be robust in most of the literature on growth or R&D and growth (see Levine and Renelt, 1992; Falk, 2007). Hence, in all of our specifications the above three variables (LY0, HCBL and INV) are included as conditional variables. We use two measures of financial development: finance activity (FA) and finance size (FS). The detail of financial development and R&D measures are given in the following two sub-sections. For further robustness, we also include the following control variables in our basic model: openness (OPEN), government size (GOV), and inflation (INF). The definitions and sources of all variables used are given in Appendix A2, Table A2.1.

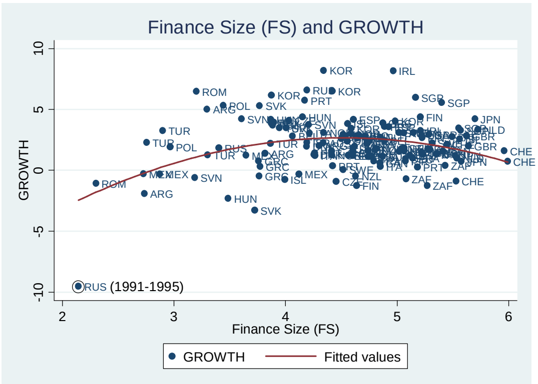
The correlations table (included in Appendix A2, Table A2.3) show that both the measures of financial development are positively related to growth. However, their scatter plots show that the relationship is not linear; it is positive for the initial levels of financial development, whereas it disappears or is possibly negative at higher levels; see Figure 2.1(a) and 2.1(b). Further, R&D intensity (BERDIND) and number of patent applications (NPATA) are positively related to growth, however they show a weak relationship which might be due to larger variations in the data; see Figure 2.1(c) and 2.1(d). We also observe that there are some outlier observations in plots (a) through (d) that may hinder our understanding of these relationships. For example, an observation with lowest GROWTH is common in all these plots which is the average growth rate of Russian Federation over the period 1991-1995. It may be due to Russia's transition from a planned economy to market economy that resulted in a sharp contraction of real per capita GDP growth during that period (see Beck et al, 2007). However, it is important to note that in multiplicative regressions with large number of observations it is almost impossible to identify outliers by simple observation of scatter plots like Figure 2.1 (see Zaman et al, 2001).

[23] Conditional convergence implies that given other factors like investment share of GDP and stock of human capital, poor countries experience faster growth rate of productivity as compared to rich countries (see Mankiw et al, 1992; Gittleman and Wolff, 1995).

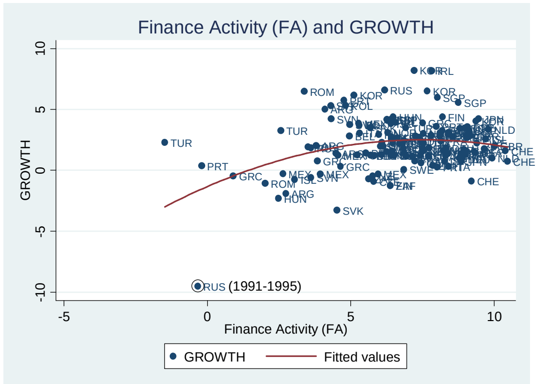
Figure 2.1: Scatter plots of Finance Size (FS), Finance Activity (FA), BERDIND and NPATA against Economic Growth (GROWTH)

Following scatter plots illustrate the relationship between two indicators of financial development (FS and FA) and economic growth (GROWTH) viz-a-viz two measures of innovation or R&D (BERDIND and NPATA) and GROWTH. GROWTH is real per capita GDP growth, FS is finance size, FA is finance activity, BERDIND is percent of BERD financed by industry, NPATA is number of patent applications per million of population. All variables are used in log form. Plot (a) shows a relationship between finance size (FS) and GROWTH, whereas plot (b) shows a relationship between finance activity (FA) and GROWTH. Plots (c) and (d) show the relationships between two measures of R&D (BERDIND and NPATA) and GROWTH. In all these plots the fitting line is based on the calculation of prediction for GROWTH from a linear regression of GROWTH on each of FS, FA, BERDIND and NPATA and their square values.

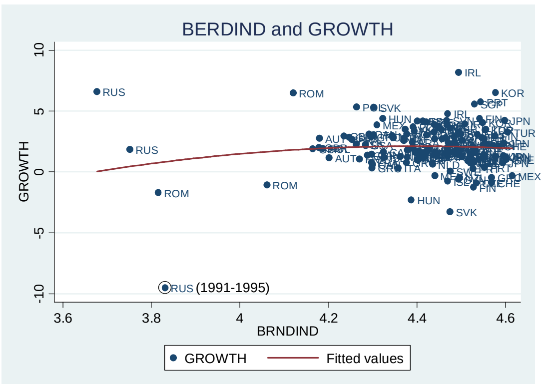
(a) Finance Size (FS) and GROWTH



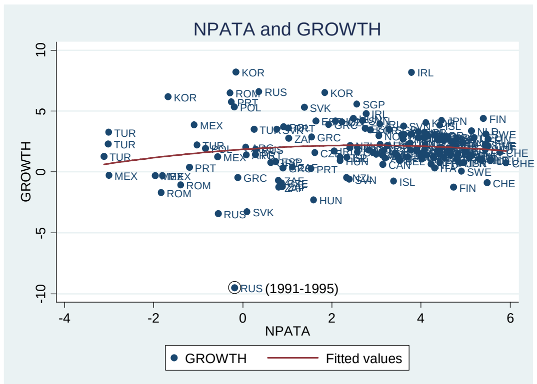
(b) Finance Activity (FA) and GROWTH



(c) BERDIND and GROWTH



(d) NPATA and GROWTH



2.3.1.1. Measures of Financial Development

The previous literature mainly uses either bank-based or market-based (or both) measures of financial development to examine their direct effects on economic growth (see King and Levine, 1993a; Gregorio and Guidotti, 1995; Levine and Zervos, 1998; Beck and Levine, 2004). However, financial services view suggests that both the banks and stock markets are important, hence stresses the need of overall financial development for economic growth.

To examine the conditional effects of financial development on economic growth we use combined measures (indexes) of financial development rather than individual and direct measures. Empirical evidence shows that combined measures perform better than the individual measures of financial development. Thus, following Beck et al (2000b), Beck and Levine (2000, 2002), and Chang et al (2005) we use two indexes to measure financial development. The first is Finance Activity (FA) which measures the overall activity in the financial sector and is constructed as the log of the product of Private Credit (value of private credit by deposit money banks as a percentage of GDP) and Trading Value (value of the total shares traded at stock exchanges as a percentage of GDP). Private Credit has certain advantages over other monetary aggregates, as it excludes the credit allocation to the public sector, thus representing more accurately the role of financial intermediaries in channelling funds to private market participants. This is the most comprehensive measure of activity of financial intermediaries which is closely related to investment efficiency and economic growth. Past studies indicate that its effect on economic growth is large, positive and significant (see King and Levine 1993a; Gregorio and Guidotti, 1995; Levine and Zervos, 1998; Beck et al, 2000b; Beck and Levine, 2004). Despite its merits, it can be a poor indicator of financial development, especially in industrial countries which have experienced significant non-bank financial innovation. However, bank-based and non-bank-based measures are positively correlated, with the impact of size being variable (see Gregorio and Guidotti, 1995). On the other hand, Trading Value represents the activity of stock market trading volume as a share of GDP and indicates the degree of liquidity provided by stock markets to economic agents rather than its size. Despite some demerits, theoretical and empirical studies on finance-growth analysis consider it an important measure of stock market development (see Levine and Zervos, 1998; Beck et al, 2000b; Rousseau and Wachtel, 2000).

Our second index is Finance Size (FS) which measures the overall size of the financial sector and is constructed as the log of the sum of Private Credit and Market Capitalization (value of listed shares, as a percentage of GDP). Market Capitalization is the measure of the size of stock markets relative to the economy. However, past studies show that it is not a good predictor of economic growth (see Levine and Zervos 1998; Beck et al, 2000b; Rousseau and Wachtel, 2000).

We use these combined measures of financial development for the following reasons: First, there is no single measure that exhibits all the functions performed by a well developed financial system. Second, as discussed earlier, according to the financial services view, overall financial development is important to promote economic growth rather than banking sector or stock market development. Third, empirical evidence supports our use of these indexes (see Beck et al, 2000b; Beck and Levine, 2002; and Chang et al, 2005). Four, our main objective is to investigate the conditional effects of financial development on economic growth rather than examining the relative importance of banks or stock markets.

2.3.1.2. Measures of Innovation or R&D Activities

Innovation may be defined as novelty or the creation of something qualitatively new using the processes of learning and knowledge accumulation, which are difficult to measure. Existing literature suggests three broad categories of indicators used in innovation analysis: R&D data, data on patents (application, grants and citations), and bibliometric data (scientific publications and citations). These measures are analogous to the measurement of research (see Smith, 2004, Ch-6). Therefore, we use one indicator from each of the input and output measures of R&D (R&D expenditures and Patent applications).

Investment in R&D is important for two reasons; first, the rate of return on R&D is many times higher than the rate of return on investment in physical capital, second, whenever R&D increases total factor productivity the latter includes capital accumulation, consequently R&D leaves both the direct and indirect effects on output growth (see Helpman, 2004, Ch-4).

Our two measures of innovation or R&D are: percentage of BERD (Business Enterprise Expenditures on R&D percent of GDP) financed by industry (BERDIND) and the total number of patent applications per million of population (NPATA), where the former measures both innovation and imitating activities, while the latter measures innovation activities only. Further, industrial R&D is most closely related to the creation of new products, production techniques, and country's innovation efforts as compared to government and higher education R&D. On the other hands, the Patent system, despite some demerits, systematically records detailed information about new technologies and their links to inventive activity (see Smith, 2004, Ch-6; Korres, 2008, Ch-1). Past studies recognize the importance of these indicators in explaining total factor productivity, being an important determinant of economic growth (see Nadiri, 1993; Coe and Helpman, 1995; Coe et al, 2008).

2.3.2. Methodology

We use panel data for 36 countries over the period 1980-2006 to analyse the impact of financial sector development on economic growth via R&D using an econometric model of the form employed by Levine et al (2000), Beck et al (2000a) and Beck and Levine (2004), and others. The model has the form:

$$y_{it} - y_{it-1} = (\alpha - 1)y_{it-1} + \gamma' X_{it} + \eta_i + \varepsilon_{it} \quad (2.1)$$

where 'y' is the logarithm of real per capita GDP, X represents a vector of explanatory variables (other than lagged real per capita GDP), η is an unobserved country specific effect which is assumed to be fixed or non-stochastic, and ε is a stochastic error term which varies with individual countries and time which is assumed to be independent and identically distributed, $\varepsilon_{it} \sim iid\ (0, \sigma^2)$. The country-specific effect captures the characteristics of individual countries that are not picked up by the regressors but which are assumed to be time invariant. The subscripts *i* and *t* represent country and time period respectively.

Specifically, for our baseline model (discussed below), the above equation can be rewritten as:

$$GROWTH_{it} = \beta_1(LY0)_{it} + \beta_2 HCBL_{it} + \beta_3 FD_{it} + \beta_4 RD_{it} + \beta_5(FD * RD)_{it} + \eta_i + \varepsilon_{it} \quad (2.2)$$

where the dependent variable is real per capita GDP growth ($GROWTH_{it}$) which is constructed as the log difference of real per capita GDP; β vector contains (α-1) and γ; $LY0_{i,t}$ is the log of initial value of real per capita GDP; $HCBL_{it}$ is the log of average years of schooling; FD_{it} is the indicator of financial development; RD_{it} is the indicator of R&D; $(FD*RD)_{it}$ is the interaction between a measure of financial development and a measure of R&D; η_i and ε_{it} are explained above. Our data covers countries i = 1, 2, …, 36 and (after time-averaging) periods t = 1, 2, 3, 4, 5.

The one-way fixed effects model of (2.2) does not take into account any unobservable time specific effect. In practice we extend this model by including a country-invariant but time-variant element (λ_t), that is,

$$GROWTH_{it} = \beta_1(LY0)_{it} + \beta_2 HCBL_{it} + \beta_3 FD_{it} + \beta_4 RD_{it} + \beta_5(FD * RD)_{it} + \eta_i + \lambda_t + \varepsilon_{it} \qquad (2.3)$$

where both η_i and λ_t are assumed to be fixed parameters to be estimated and ε_{it} satisfies the assumptions above. For simplicity of exposition, however, our discussion of estimation focuses primarily on the form given in (2.2).

A number of panel data techniques are used in the growth literature to estimate econometric models like (2.2). Following Islam (1995), Caselli et al (1996) and Arellano and Bover (1995), we use a range of estimators, namely fixed effects, difference GMM and system GMM methods. These are briefly explained in the following subsections.

2.3.2.1. Fixed Effects Estimation

Equation (2.2) can be written in the form that includes a dummy variable for each country i and then estimated by OLS, leading to the least squares dummy variable (LSDV) estimator. However, the LSDV estimator is unattractive when it includes many regressors. Fortunately, this can be avoided by eliminating the country specific fixed effects (η_i) by expressing the data as deviations from individual country means.

Averaging (2.2) over time for each i = 1, …, 36 and subtracting the result from (2.2) gives

$$\begin{aligned}(GROWTH_{it} - \overline{GROWTH}_{i.}) = \beta_1(LY0_{it} - \overline{LY0}_{i.}) + \beta_2(HCBL_{it} - \overline{HCBL}_{i.}) \\ + \beta_3(FD_{it} - \overline{FD}_{i.}) + \beta_4(RD_{it} - \overline{RD}_{i.}) \\ + \beta_5(FD*RD_{it} - \overline{FD*RD}_{i.}) + (\varepsilon_{it} - \bar{\varepsilon}_{i.})\end{aligned} \qquad (2.4)$$

This is called the within transformation and the corresponding OLS estimator applied to (2.4) is known as the within estimator or fixed-effects estimator. Given the estimates of $\beta_1, \beta_{2,\dots,} \beta_5$ from equation (2.4), we can recover estimates of the country-fixed effects (η_i) by substituting the coefficient estimates from (2.4) in the equation for mean growth.

Consistency of an estimator is usually achieved by requiring the disturbances, $(\varepsilon_{it} - \bar{\varepsilon}_{i.})$ in (2.4), to be uncorrelated with the (transformed) regressors. However, the presence of the dynamic term *LY0*, or any other variable that depends upon the history of dependent variable (*GROWTH*), will violate this assumption (see Verbeek, 2004), because $\overline{LY0}_{i.}$ is correlated with ε_{it} by construction. This correlation becomes negligible only for sizeable *T*, which does not apply in our case of time-averaged data. Thus we may anticipate biased regression coefficient estimates (see Nickell, 1981; Judson and Owen, 1999; Eberhardt and Teal, 2011). Further, fixed-effects estimation does not permit any of the other regressors in (2.4) to be endogenous.

We now turn to the extended model of (2.3), which is known as a two-way fixed effects model. In this case, the estimates of $\beta_1, \beta_{2,\dots,} \beta_5$ can be obtained by performing within transformation two times: first, over time to eliminate country-specific effects (η_i) and second, over countries to eliminate time-specific effects (λ_t) as suggested by Wallace and Hussain (1969) (see Baltagi 2005). If time-specific effects (λ_t) are significant then the one-way fixed-effects estimator will suffer from omitted variables bias. We use the *xtreg* command in Stata 9.2 to get fixed effects estimates of (2.2) and (2.3) which are robust to cross-sectional heteroskedasticity and within-panel serial correlation.

Testing for country-specific and time-specific effects

In the context (2.3), we test the joint significance of country-specific fixed effects by using an *F-test*. This is a simple Chow test where the restricted residual sum of squares (RRSS) is obtained from a pooled OLS regression of (2.2) under the assumption that all η_i are equal and the unrestricted residual sum of squares (URSS) is obtained from the within transformation over time (2.4). However, this test is not valid for a dynamic model, due to the bias of the fixed effects estimator in this case. Similarly, we test for the significance of time-specific effects allowing for country-specific effects; where, the unrestricted residual sum of squares (URSS) is obtained from the within transformation over countries.

2.3.2.2. Difference and System GMM Estimation

As discussed above, the within transformations wipe out the country specific and time specific fixed effects but the presence of initial real per capita GDP ($LY0_{it}$) in (2.2) may cause problems with bias in our relatively small sample of five time periods. Moreover, we wish to treat the other explanatory variables as potentially endogenous due to the possible feedback effects from growth to these. Contrary to cross-sectional regressions, dynamic panel regressions use internal instruments, which are the lagged values of the instrumented variables. Therefore, in order to find consistent estimates of the above equation under these conditions, we use the difference GMM estimator for a dynamic panel data models as suggested by Arellano and Bond (1991). This approach differences (2.2) over time to eliminate the country specific effects:

$$\Delta GROWTH_{i,t} = \beta_1 \Delta(LY0)_{i,t} + \beta_2 \Delta(HCBL)_{i,t} + \beta_3 \Delta FD_{i,t} + \beta_4 \Delta RD_{i,t} + \beta_5 \Delta(FD * RD)_{i,t} + \Delta\varepsilon_{i,t} \qquad (2.5)$$

Although this procedure eliminates the country specific effects (η_i), it introduces the MA(1) disturbance $\Delta\varepsilon_{i,t} = \varepsilon_{i,t} - \varepsilon_{i,t-1}$ in (2.5) and does not remove any correlation between the right hand side regressors and the error. Due to the MA(1), one period lagged endogenous regressors are not valid instruments. To address this issue, Arellano and Bond (1991) suggest that at least two-period lags of the regressors should be used as instruments for current differences of the endogenous variables. Hence, assuming that the regressors in (2.2) are potentially endogenous and that the original error terms ε_{it} are serially uncorrelated, the following moment conditions must be satisfied in our case:

$$
\begin{aligned}
&E[LY0_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \ s \geq 2; t = 3,4,5 \\
&E[HCBL_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \ s \geq 2; t = 3,4,5 \\
&E[FD_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \ s \geq 2; t = 3,4,5 \qquad (2.6) \\
&E[RD_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \ s \geq 2; t = 3,4,5 \\
&E[(FD * RD)_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \ s \geq 2; t = 3,4,5
\end{aligned}
$$

Using these moment conditions, Arellano and Bond (1991) propose a two step GMM difference estimator, where in the first step the error terms ε_{it} are assumed to be *i.i.d.* across countries and time, while in the second step, the *i.i.d.* assumption over countries is relaxed and a consistent estimate of the cross-country variance-covariance matrix is obtained using the residuals from the first step. This estimator is asymptotically consistent but likely to exhibit large biases in the reported standard errors in samples with a small number of time series observations (see Windmeijer, 2005). Hence the one-step GMM estimator may be preferred.

In addition to problems with standard errors, Arellano and Bover (1995) show that the coefficients estimated using difference GMM are likely to show substantial small sample biases when 'T' is small and 'N' is large. Their procedure is supported by the Monte Carlo studies conducted by Blundell and Bond (1998) which show that the inclusion of a level equation in the estimation reduces the potential biases in finite samples and the asymptotic imprecision associated with the difference estimator. They discuss how the information contained in levels can be exploited in the estimation. That is, in addition to the moment conditions (2.6), it is also possible to use valid instruments for the level equation (2.2). The country-specific effects (η_i) in the level equation (2.2) are controlled by the use of suitable instruments rather than eliminating them. For example, the lagged differences of the corresponding variables may be candidate instruments given that the correlations between country-specific fixed effects and right hand side level variables in equation (2.2) are constant over time. This assumption is based on the following stationarity conditions:

$$
\begin{aligned}
&E[LY0_{i,t+p}.\eta_i] = E[LY0_{i,t+q}.\eta_i] && \forall \ \text{p and q} \\
&E[HCBL_{i,t+p}.\eta_i] = E[HCBL_{i,t+q}.\eta_i] && \forall \ \text{p and q} \\
&E[FD_{i,t+p}.\eta_i] = E[FD_{i,t+q}.\eta_i] && \forall \ \text{p and q} \qquad (2.7) \\
&E[RD_{i,t+p}.\eta_i] = E[RD_{i,t+q}.\eta_i] && \forall \ \text{p and q} \\
&E[(FD * RD)_{i,t+p}.\eta_i] = E[(FD * RD)_{i,t+q}.\eta_i] && \forall \ \text{p and q}
\end{aligned}
$$

Therefore, the additional moment conditions for the second part of the system (the regression in levels) are given by the following equations:

$$
\begin{aligned}
&E[\Delta LY0_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1 \text{ and t} = 3,4,5 \\
&E[\Delta HCBL_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1 \text{ and t} = 3,4,5 \\
&E[\Delta FD_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1 \text{ and t} = 3,4,5 \qquad (2.8) \\
&E[\Delta RD_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1 \text{ and t} = 3,4,5 \\
&E[\Delta (FD * RD)_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1 \text{ and t} = 3,4,5
\end{aligned}
$$

where s=1 is used to avoid redundant instruments. Given the moment conditions in (2.6) and (2.8), the GMM system estimator generates efficient and consistent estimates of the parameters in equation (2.2). However, it is evident from the moment conditions given in (2.6) and (2.8) that they increase as we increase the number of time periods (*T*): the overall count is typically quadratic in *T* because each instrumenting variable generates one column in the instrument matrix for each time period and its lags (see Roodman, 2006; 2009). Consequently, this over-fitting of instrumented variables, especially in small samples like 5 periods and 36 countries, may fail to wipe out their endogenous components and result in biasing the coefficients towards those without instrumentation. Moreover, it may bias the Sargan/ Hansen test towards over-accepting the null hypothesis (see Beck, 2008; Roodman, 2006, 2009).

To correct for these problems, we use a collapsed matrix of instruments as suggested by Roodman (2006, 2009), which creates one instrument for each variable and lag distance, rather than one for each time period, variable, and lag distance. Thus, the new sets of moment conditions for difference and level equations are given as:

For difference equation

$$
\begin{aligned}
&E[LY0_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \; s \geq 2 \\
&E[HCBL_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \; s \geq 2 \\
&E[FD_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \; s \geq 2 \qquad (2.6)^* \\
&E[RD_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \; s \geq 2 \\
&E[(FD * RD)_{i,t-s}.\Delta\varepsilon_{i,t}] = 0, && \forall \; s \geq 2
\end{aligned}
$$

For level equation

$$
\begin{aligned}
&E[\Delta LY0_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1 \\
&E[\Delta HCBL_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1 \\
&E[\Delta FD_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1 \qquad (2.8)^* \\
&E[\Delta RD_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1 \\
&E[\Delta (FD * RD)_{i,t-s}.(\eta_i + \varepsilon_{i,t})] = 0 && \text{for s} = 1
\end{aligned}
$$

We use one-step and two-step difference and system GMM estimators for the estimation of equation (2.3) using time dummies as strictly exogenous regressors in all regressions. For estimation purpose, we use *xtabond2* command in Stata 9.2 written by Roodman (2003) which implements difference and system GMM, while making the Windmeijer (2005) finite-sample correction to the reported standard errors in two-step estimation.

2.3.2.3. Diagnostic Tests

The consistency of the GMM estimator discussed above depends upon the validity of the instruments and the assumption of no serial correlation in the error terms $(\varepsilon_{i,t})$. Arellano and Bond (1991) suggest two tests in this context; Sargan's (1958) test of over-identified restrictions and a second order serial correlation test of difference error terms ($\Delta\varepsilon_{it}$). We use Hansen's (1982) *J*-test which is a general version (for GMM models) of Sargan's (1958) test to examine the validity of instruments. It follows χ^2 distribution with *(J-K)* degrees of freedom, where *J* is the number of instruments and *K* is the number of endogenous variables, under the null hypothesis that the instrumented variables are uncorrelated with the residuals. Failure to reject the null hypothesis supports the validity of our instruments. This test becomes biased in the case of over-identification of instruments; therefore a simple rule of thumb is to keep the number of instruments equal to or less than the number of groups or countries (see Stata 9.2).

Our second test examines the assumption that there is no second order serial correlation in the first differenced error term ($\Delta\varepsilon_{it}$) because by construction it is a first-order moving average. Second-order serial correlation of the differenced residuals supports the assumption that the original error term is serially correlated. If the test fails to reject the null hypothesis of no second-order serial correlation, we conclude that the original error term is serially uncorrelated and use the corresponding moment conditions (see Calderon et al 2002).

2.3.2.4. Discussion

Past growth literature is mostly based on cross-sectional analysis of a large sample of developed and developing countries. However, cross-sectional analysis of growth regressions does not take into account unobservable country specific effects and endogeneity. On the other hand a panel data framework makes it possible to allow for unobservable country specific differences in technology or preferences. However, it is unclear which panel data estimator is preferable to estimate a dynamic growth regression. The least squares dummy variable (LSDV) or Fixed-Effects (FE) estimator is used by Islam (1995). Although the FE estimator takes care of country specific effects, it is not an ideal candidate due to the presence of the lagged dependent variable as an explanatory variable because it assumes that the transformed explanatory variables and error terms are uncorrelated. Thus, the presence of the lagged dependent variable as an explanatory variable makes LSDV or FE estimator inconsistent when the asymptotics are considered in the direction $N \rightarrow \infty$ (see Islam, 1995).

However, it is proven to be a consistent estimator if the asymptotics are considered in the direction $T \rightarrow \infty$, in which case it is asymptotically equivalent to maximum likelihood estimator and performs quite well in the Monte Carlo studies (Islam, 1995). Hence, in macro panels where T is not very small relative to N we may still favour the FE or within estimator arguing that its bias may not be large (see Islam, 1995). Other Monte Carlo studies for N=20 or 100 and T=5, 10, 20 and 30 finds that the bias in FE estimator can be sizeable, even when T=30 it is as much as 20% of the true value of the coefficient of interest (see Judson and Owen, 1999; Baltagi, 2005). Therefore, in growth regressions where T is very small as compared to number of countries or groups (such as our case with N=36 and T=5) the FE estimator may produce substantially biased estimates of our dynamic growth regression (see Bond et al 2001). In sum, although FE estimation wipes out the country specific fixed effects it largely ignores dynamics. Further, it takes no account that regressors, other than the lagged dependent variable, may be endogenous.

Caselli et al (1996) are the first to address both the problems of country specific effects and endogeneity in their growth regressions. They implement difference GMM estimator suggested by Arellano and Bond (1991). As discussed above, in difference GMM estimation, the country specific fixed effects are eliminated by taking first difference of the level equation, whereas the problem of endogeneity is solved by instrumenting the first differences of endogenous variables at levels by their corresponding lagged values. Caselli et al (1996) show that the difference GMM estimator produces consistent estimates which in turn depend on the validity of instruments used.

However, despite the above mentioned advantages of difference GMM estimator there are serious drawbacks associated with the implementation of these estimators in dynamic growth regressions. For example, in the presence of weak instruments, GMM estimation of the dynamic growth regression may cause large finite sample biases (see Bond et al, 2001). Further, difference GMM estimator performs poorly when the time series are persistent with small T because under these conditions lagged levels are weak instruments for corresponding first-differences (see Bond et al, 2001). In the context of empirical growth (convergence) literature, Bond et al (2001) show that if pooled OLS is applied to a dynamic growth regression, it produces estimates which are upward biased while the FE estimator produces downward biased estimates. Further, they document that difference GMM estimator produces estimates that lie below the estimates of fixed effects which indicates that the former estimates are downward biased. They suggest two solutions in this context: first, using the system GMM estimator as suggested by Arellano and Bover (1995) which produces estimates that lie between OLS and FE estimates; two, adding outside instruments in the dynamic growth regression (e.g. lagged human capital variable) which may improve the difference GMM estimates towards FE estimates. They suggest that it is always difficult to strengthen the set of instrument variables by including outside instruments, thus recommending system GMM estimator in growth regressions with short panels. Further, they suggest that these estimates should always be compared with other results obtained from OLS, FE or difference GMM estimators.

Overall, the above discussion indicates that if there are significant dynamics in our growth regression (explained in next subsection) then the preference should be given to the system GMM estimator (especially in short panels) that takes care of country specific fixed effects as well as endogeneity and produces consistent estimates. On the other hand, the difference GMM estimator produces large biases in small samples. However, in circumstances when T is relatively large we may consider fixed-effects estimator because in this case it may result in small biases, but only when none of the other regressors is endogenous. As our sample consists of 36 countries and five time periods, we anticipate that the system GMM estimator will perform well, compared with other available approaches. However, in case of insignificant dynamics in our growth regression other estimators may be relevant. Therefore, we estimate our growth regression using these three estimators outlined above.

2.3.2.5. Hampel Identifier (A Rule to identify outliers)

In our estimation, we also take into account the presence of influential outliers in the data, which is quite likely in a group of heterogeneous countries as shown in Figure 2.1. As there is no robust estimator like least trimmed squares (LTS) available for dynamic panel data models, we use the *Hampel Identifier* as given in Wilcox (2005) to identify the possible outliers in the data. We use a cut-off value of 2.24 except in difference GMM estimation which uses a value of 3.5 (as used by Hampel; see Wilcox, 2005) because in this case the former value results in a large number of outlier observations which may be harmful for our small data set. We apply the *Hampel Identifier* to the regression residuals stacked over time and individual countries (R_i) and treat any observation as an outlier for which the following is true:

$$HI = \frac{|R_i - M|}{MADN} > 2.24 \qquad (2.9)$$

where M is the median of R_1, R_2, …, R_n observations, MADN=MAD/0.6745, MAD is the median of the values $|R_1 - M|,...,|R_n - M|$, 0.6745 is 0.75 quantile of standard normal distribution, and 2.24 is 0.975 quantile of chi-square distribution with one degree of freedom. This estimator has the highest possible breakdown value of 0.5; that is, it can withstand up to 50% of the data being outliers. More clearly, *HI* does not produce very large or very small estimates due to the presence of outlier observations (as compared to the case of no outliers) until the outliers exceed 50% of the data points. Its efficiency remains high even when samples are drawn from heavy tailed distributions (see Wilcox, 2003). Our approach is to estimate all models using full data set and then re-estimate them after excluding the outlier observations.

2.4. Estimation and Results

In this section, we use finance size (FS) and finance activity (FA) as measures of financial development and examine their conditional effects on economic growth using R&D intensity (BERDIND) as a measures of innovation or R&D. Following the empirical literature on economic growth, we use fixed effects, difference GMM, and system GMM methods for the estimation of our econometric model (see Islam, 1995; Caselli et al 1996; Arellano and Bond, 1991; Arellano and Bover, 1995; Bond et al, 2001). To check whether our results are sensitive to potential outliers in the data, we apply the *Hampel Identifier* to residuals in order to detect outlier observations.

In each model we include the initial real per capita GDP (LY0), a measure of human capital (HCBL), and investment to GDP ratio (INV) as conditional variables, whereas the other control variables are openness (OPEN), government size (GOV) and inflation (INF). We utilize the general to specific approach in two-way fixed effects and one-step difference GMM estimations, whereas one-step system GMM estimation includes one control variable at a time with our conditional variables. This latter choice is made due to the limitations of available data and the number of instruments.

Table 2.1 reports the two-way fixed effects estimates of the conditional effects of finance size (FS) on growth using R&D intensity (BERDIND) as a measure of R&D. Models (1) and (3) use full data set, whereas models (2) and (4) exclude outliers from the data[24]. Model (1) shows that the sign of LY0 is negative and significant at the 1% level which is consistent with the theoretical literature on convergence (see Aghion et al, 2005). The sign of the human capital variable (HCBL) is positive but insignificant. Empirical literature shows mixed evidence on the sign and significance of human capital variable (see Temple, 1998, 1999; Benhabib and Spiegel, 2000; Beck and Levine, 2004). Investment to GDP ratio

[24] The list of excluded outliers from our analysis is given in Appendix A2, Table A2.4.

(INV) is positive and significant at the 1% level ,which is consistent with the growth literature in general and the R&D-growth literature in particular (see Barro, 1991; Levine and Renelt, 1992; Caselli et al 1996; Falk, 2007). The coefficient of openness (OPEN) is positive and insignificant, whereas the coefficient of government size (GOV) is negative and insignificant. Inflation (INF) is negative and significant at 1% level which is consistent with the empirical literature on inflation and growth (see Fischer, 1993). The coefficients on finance size (FS) and BERDIND are positive and significant at 1% and 5% levels respectively, which are consistent with most of the empirical literature (despite some exceptions).

However, the interaction term (FS*BERDIND) is negative and significant at 1% level. It sheds light on our conditional hypothesis that the relationship between financial development and economic growth is conditional upon the level of R&D activity; where, the effect of financial development on economic growth decreases as R&D increases. Model (2) excludes four outlier observations[25] and finds openness (OPEN) to be significant at 5%, which was insignificant in model (1). Further, significance of the coefficient on BERDIND improves from the 5% to 1% level, while the remainder of the results are qualitatively the same in these two sets of coefficients.

Following the general-to-specific approach, models (3) and (4) exclude GOV, which is insignificant in model (2). Models (3) and (4) show similar results as model (2), with small variations in the magnitudes of the regression coefficients. After excluding outliers in (4), the partial derivative of GROWTH with respect to finance size (FS) is estimated to be:

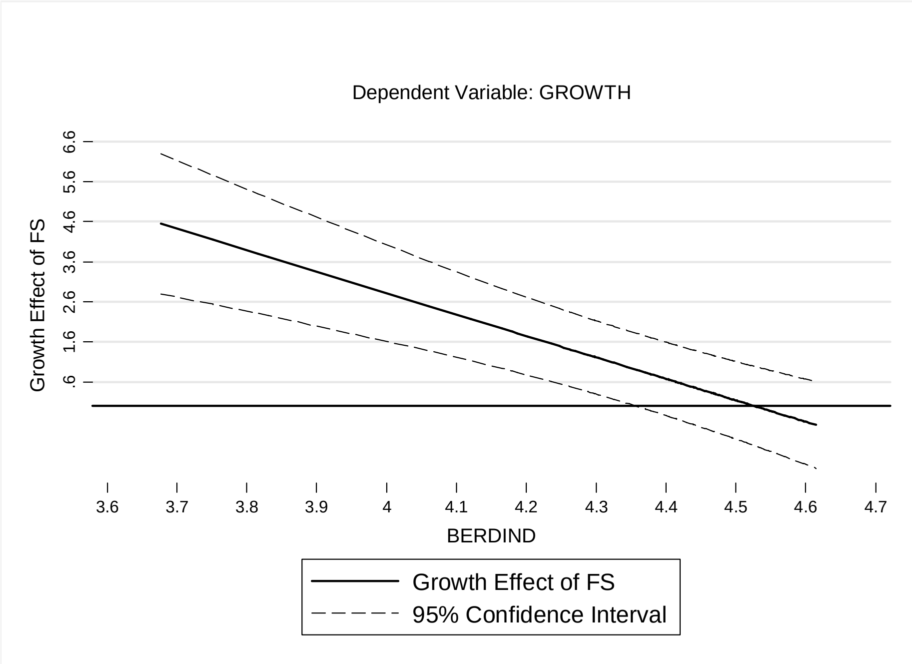
$$\frac{\partial GROWTH}{\partial FS} = 24.247 - 5.357.BERDIND \qquad (2.10)$$

The above derivative gives us the total effect of FS, which decreases as the level of BERDIND increases. As the two coefficients in equation (2.10) are of opposite signs, we evaluate this derivative within the sample by substituting the BERDIND values in it. It confirms that at a very high level of BERDIND adding FS

[25] These outliers are different from that could be identified in scatter plots of Figure 2.1. It may be because in multivariate regressions with large number of observations it is almost impossible to detect outliers by observing simple scatter plots; the reason being that the effect of one outlier is very likely to be masked by the presence of others (see Zaman et al, 2001).

reduces economic growth (GROWTH), whereas it is positive at low levels of BERDIND (See Figure 2.2).

Figure 2.2: Growth Effect of Finance Size (FS) as BERDIND Changes (Two-way Fixed Effects)



This figure shows that in countries where investment in business R&D (BERDIND) is high, financial sector development plays a minimal role in promoting growth. This observation is important especially in the context of financial crises. Our result is consistent with the view that countries with a very high level of innovation or R&D may experience excessive financial innovation or credit booms that deteriorate credit standards, increase growth of non-performing loans and cause bank crises in these countries. Consequently, in the wake of excessive financial innovation or financial crisis, the effect of financial development on economic growth decreases and even becomes negative as shown by Figure 2.2.

Table 2.1: Growth Effect of Finance Size (FS) as Percentage of BERD Financed by Industry (BERDIND) Changes, Two-way Fixed Effects

Two-way Fixed Effects				
	(1)	(2)	(3)	(4)
VARIABLES	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers
LY0	-13.612*** (0.000)	-13.094*** (0.000)	-14.184*** (0.000)	-14.527*** (0.000)
HCBL	4.904 (0.362)	-0.343 (0.926)	1.247 (0.816)	-0.686 (0.803)
INV	5.525*** (0.000)	5.886*** (0.000)	5.815*** (0.000)	5.660*** (0.000)
OPEN	1.664 (0.138)	2.818** (0.010)	2.391** (0.046)	2.769** (0.010)
GOV	-4.838 (0.103)	-1.630 (0.457)		
INF	-0.812*** (0.007)	-0.686** (0.019)	-0.686** (0.022)	-0.644** (0.026)
FS	20.770*** (0.003)	24.058*** (0.000)	22.053*** (0.001)	24.247*** (0.000)
BERDIND	18.553** (0.018)	22.756*** (0.000)	20.575*** (0.007)	23.794*** (0.000)
FS*BERDIND	-4.594*** (0.003)	-5.236*** (0.000)	-4.893*** (0.002)	-5.357*** (0.000)
Time Dummies				
1986-1990	3.334** (0.033)	4.137*** (0.002)	3.587*** (0.009)	4.150*** (0.001)
1991-1995	3.559** (0.030)	4.421*** (0.001)	3.935*** (0.007)	4.642*** (0.000)
1996-2000	4.721*** (0.007)	5.518*** (0.000)	5.391*** (0.001)	5.946*** (0.000)
2001-2006	5.874*** (0.002)	6.377*** (0.000)	6.531*** (0.000)	7.064*** (0.000)
Constant	22.613 (0.639)	-6.880 (0.857)	8.971 (0.843)	0.263 (0.994)
Observations	121	117	121	116
R-squared	0.840	0.886	0.830	0.897
Number of countries	36	36	36	36
F-test for country effects (p-values)	0.000	0.000	0.000	0.000
F-test for time dummies (p-values)	0.001	0.000	0.000	0.000

Notes: The p-values are reported in brackets. ***, **, * indicate significance at 1%, 5%, and 10% respectively. All models employ robust standard errors. The dependent variable is real per capita GDP growth. FS is finance size. BERDIND is percent of BERD financed by industry. FS*BERDIND is the interaction term between FS and BERDIND. Outliers are removed in (2) and (4) based on the *Hampel Identifier* applied to the residuals of (1) and (3), respectively.

As Table 2.1 shows a significant dynamic term in all cases (that is, LY0 is significant), the Two-way Fixed Effects methodology may render biased regression estimates. Therefore, in Table 2.2 we use the one-step difference GMM estimator for dynamic panels as suggested by Arellano and Bond (1991) and employed by Caselli et al (1996). In Table 2.2, model (1) shows that the coefficients on finance size (FS) and BERDIND are positive and significant at 1% and 10% levels respectively, whereas their interaction (FS*BERDIND) is negative and significant at the 5% level. However, model (2) that excludes a single outlier observation (Romania, 1996-2000) shows that the significance of inflation (INF) increases from 10% to the 5% level. Further, the significance of FS decreases from 1% to 5% level, BERDIND is insignificant now, and the coefficient on FS*BERDIND increases from -5.127 to -4.599. Model (3) excludes government size (GOV) and shows that the estimated coefficient on HCBL and its significance changes from model (2) to (3), which may be because it is correlated with GOV. Further, openness (OPEN) is now significant at 10% which was insignificant in model (2); however, the significance of inflation (INF) decreases from 5% to 10%. Moreover, we observe that both the size and significance of the coefficients on FS, BERDIND and FS*BERDIND improves. These three variables are now significant at 1% level, whereas BERDIND was insignificant in model (2). We find no outlier observation in model (3). The results of Table 2.2 are fully consistent with our findings in Table 2.1.

Theoretical and empirical literature outlined in section 2.3 suggests that in dynamic panels the difference GMM estimator may produce unreliable estimates because of poor instrument variables. Thus, in Table 2.3 we use one step system GMM estimator for dynamic panels as suggested by Arellano and Bover (1995) and Blundell and Bond (1998). In Table 2.3, models (1), (3), and (5) utilize the full data set while models (2), (4), and (6) exclude outlier observations. A limitation of this analysis is that we do not include all variables at once in our estimation regression because in that case the number of instruments exceeds the number of groups or countries. Following the rule of thumb, we include the maximum number of variables for which the number of instruments is less than the number of countries (see Stata 9.2). Hence, we add one further control variable at a time, in addition to our three conditioning variables: LY0, HCBL and INV.

In model (1) we add openness (OPEN) as a control variable and find that all the conditional and control variables are insignificant, particularly INV is negative

Table 2.2: Growth Effect of Finance Size (FS) as Percentage of BERD Financed by Industry (BERDIND) Changes, One-Step Difference GMM

	(1)	(2)	(3)
VARIABLES	All Obs.	Excludes Outliers	All Obs.
LY0	-13.295*** (0.000)	-12.686*** (0.000)	-12.031*** (0.000)
HCBL	-4.134 (0.742)	-3.488 (0.738)	-9.324* (0.088)
INV	5.074*** (0.003)	4.546*** (0.004)	5.264*** (0.003)
OPEN	3.768* (0.092)	3.052 (0.143)	4.881* (0.082)
GOV	-3.819 (0.632)	-4.686 (0.483)	
INF	-0.720* (0.066)	-0.757** (0.040)	-0.712 (0.100)
FS	23.072*** (0.010)	20.720** (0.017)	29.764*** (0.000)
BERDIND	17.237* (0.078)	14.287 (0.138)	23.233*** (0.006)
FS*BERDIND	-5.127** (0.011)	-4.599** (0.021)	-6.760*** (0.000)
Time Dummies			
1986-1990	3.307* (0.093)	3.069 (0.123)	3.428** (0.043)
1991-1995	3.996* (0.070)	3.604* (0.094)	4.207** (0.021)
1996-2000	5.204** (0.048)	4.879** (0.049)	5.664*** (0.005)
2001-2006	6.341** (0.013)	5.942** (0.014)	6.603*** (0.002)
Observations	85	84	85
Number of countries	33	32	33
Number of instruments	31	31	28
F-Statistic (overall)	0.000	0.000	0.000
Hansen J-test (p-value)	0.18	0.21	0.24
Arellano-Bond AC(1) test (p-value)	0.88	0.76	0.81
Arellano-Bond AC(2) test (p-value)	0.92	0.82	0.59

Notes: As for Table 2.1. Model (3) uses all the data and it does not exclude any outlier because we are unable to detect any outlier observation in this case using *Hampel Identifier*. *Hansen J-test* is used to test the validity of instruments, whereas Arellano-Bond AC(1) and AC(2) tests are used to test the presence of first and second order serial correlation of the differenced residuals.

Table 2.3: Growth Effect of Finance Size (FS) as Percentage of BERD Financed by Industry (BERDIND) Changes, One-Step System GMM

One-Step System GMM						
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers
LY0	-2.749 (0.131)	-1.446 (0.174)	-2.395 (0.206)	-1.539 (0.333)	-3.431** (0.037)	-2.904** (0.021)
HCBL	-0.869 (0.829)	-0.595 (0.760)	1.570 (0.677)	0.656 (0.835)	-2.419 (0.554)	-2.553 (0.313)
INV	-1.892 (0.406)	-2.589 (0.378)	-0.326 (0.858)	-1.271 (0.639)	-2.210 (0.389)	-1.314 (0.503)
OPEN	-0.368 (0.798)	1.634 (0.209)				
GOV			-3.047 (0.322)	-4.487* (0.077)		
INF					-0.658 (0.369)	-0.800 (0.197)
FS	34.054*** (0.006)	35.361*** (0.000)	34.749*** (0.006)	35.655*** (0.003)	25.977 (0.144)	33.510*** (0.001)
BERDIND	31.199** (0.016)	30.075*** (0.000)	30.018** (0.019)	29.735*** (0.009)	24.448 (0.199)	33.174*** (0.004)
FS*BERDIND	-7.051** (0.019)	-7.748*** (0.000)	-7.194** (0.018)	-7.584*** (0.009)	-5.252 (0.205)	-7.319*** (0.002)
Time Dummies						
1986-1990	3.097* (0.060)	2.288** (0.047)	3.068** (0.021)	3.412*** (0.007)	2.990* (0.086)	3.519** (0.017)
1991-1995	1.603 (0.398)	0.331 (0.806)	1.706 (0.210)	2.051 (0.125)	1.481 (0.437)	2.272 (0.159)
1996-2000	3.005 (0.120)	2.026 (0.139)	2.604* (0.064)	2.605* (0.085)	2.513 (0.268)	3.432* (0.056)
2001-2006	2.008 (0.345)	1.051 (0.489)	1.630 (0.255)	1.901 (0.219)	1.479 (0.493)	2.881* (0.098)
Constant	-115.792* (0.051)	-120.821*** (0.001)	-117.133** (0.042)	-111.095** (0.033)	-74.722 (0.412)	-114.005** (0.040)
Observations	124	118	126	119	123	117
Number of Countries	36	35	36	35	36	35
Number of instruments	33	33	33	33	33	33
F-Statistic (overall)	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J-test (p-value)	0.28	0.27	0.12	0.11	0.24	0.26
Arellano-Bond AC(1) Test (p-value)	0.22	0.07	0.11	0.02	0.28	0.07
Arellano-Bond AC(2) Test (p-value)	0.43	0.33	0.41	0.53	0.41	0.92

Note: As for Tables 2.1 and 2.2. Models (1), (3) and (5) use full data set, whereas models (2), (4) and (6) exclude the outlier observations.

but insignificant which is contrary to our previous findings. The coefficients on FS and BERNDIND are positive and significant at 1% and 5% levels respectively. The interaction term is still negative and significant at the 1% level. However, excluding outliers in this case improves the significance of BERDIND and the interaction from the 5% to 1% level. In model (3), we use government size (GOV) as a control variable which is negative and insignificant. Empirical literature on fiscal variables and growth shows that their relationship is statistically fragile which may partly be due to multicollinearity between fiscal variables and the initial income level as shown in Appendix, Table A2.3 (see Easterly and Rebelo, 1993). However, excluding outliers in model (4) renders its significance at the 10% level.

Finally, we use inflation (INF) in our basic model, as shown in model (5). Inflation bears a negative sign which is consistent with the literature on inflation and growth (see Fischer, 1993). The coefficient on LY0 is negative and significant at 5% level which is consistent with our results in Tables 2.1 and 2.2, whereas all other coefficients are insignificant. However, excluding outliers renders significant coefficients on FS, BERDIND and their interaction as shown in model (6).

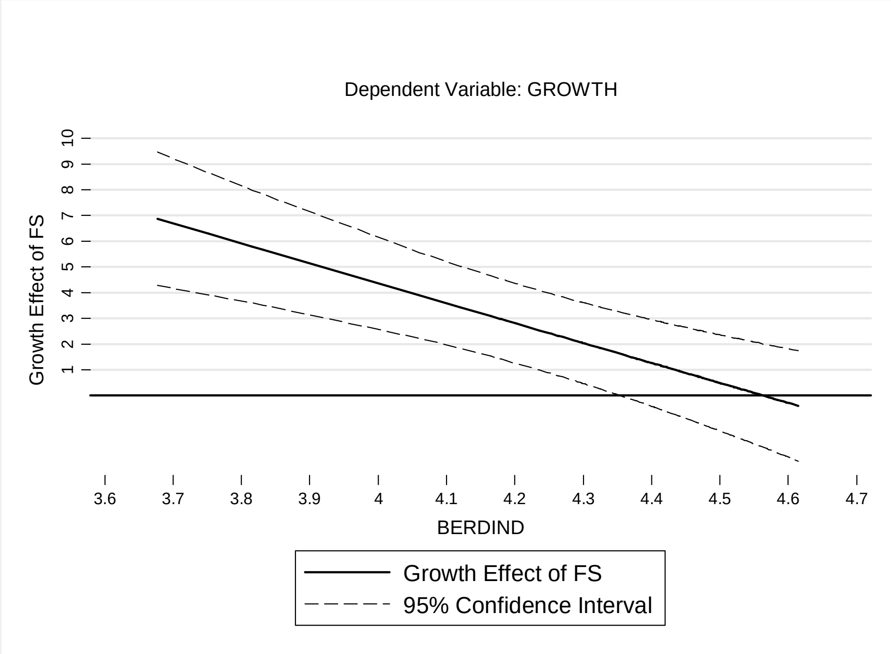
Using model (2) as being representative of the baseline results in Table 2.3, after exclusion of outliers, the partial derivative of GROWTH with respect to finance size (FS) is given as:

$$\frac{\partial GROWTH}{\partial FS} = 35.361 - 7.748.BERDIND \qquad (2.11)$$

Evaluating this derivative within the sample by substituting the BERDIND values in it gives us the same result as (2.10), that is, at very high levels of BERDIND adding FS reduces economic growth (GROWTH), whereas it is positive at low levels of BERDIND (See Figure 2.3). Hence, these results are consistent with our previous findings from two-way fixed effects estimation as shown in Table 2.1. Further, our diagnostic tests confirm that the instruments used in the analysis of Table 2.2 and 2.3 are valid and that there is no second order serial correlation.

Overall, the regression estimates from Tables 2.1-2.3 show that the effects of financial development and R&D on growth are positive and significant, whereas their interaction leaves negative and significant effect.

Figure 2.2: Growth Effect of Finance Size (FS) as BERDIND Changes (One-Step System GMM)



2.4.1. Robustness Checks

In order to test whether our results are sensitive to different measures of financial development, we use a new measure of financial development (finance activity, FA). The results using this new measure of financial development are reported in Tables 2.4 through 2.6. Comparing the coefficients on FA, BERDIND and their interaction (FA*BERDIND) in our representative models of these tables (that exclude outliers) we find that the overall results are consistent with our main findings as shown in section 2.4. For example, model (4) in Table 2.4 excludes GOV which was insignificant in models (1) and (2) and shows that FA and BERDIND are positive and significant at 1% level, whereas their interaction (FA*BERDIND) is negative and significant at 1% level. Same significance on these coefficients is obtained in model (2) of Table 2.6 with relatively larger coefficients. Model (3) in Table 2.5 shows that FA and BERDIND are positive and significant at 1% and 10% level respectively, while FA*BERDIND is negative and significant at 1% level. Further, we note that country and time specific effects in Table 2.4 are significant at 1% level in models (1) through (4). In Tables 2.5 and 2.6 the test for validity of instruments (*Hansen J-test*) fails to reject the null hypothesis of no correlation between regressors (instruments) and residuals. Moreover, Arellano and Bond (1991) test for second order serial correlation fails to reject the null hypothesis of no second order serial correlation in the error term.

A comparison of results from Tables 2.4-2.6 and Tables 2.1-2.3 suggest that the findings are effectively unchanged because FS and FA are strongly correlated (see Appendix, Table A2.3). To compare the behaviour of growth effect of financial development as R&D changes, we use model (2) of Table 2.6 to calculate the partial derivative of GROWTH with respect to FA given as:

$$\frac{\partial GROWTH}{\partial FA} = 11.857 - 2.582.BERDIND \qquad (2.12)$$

where the evaluation of this derivative within the sample shows that the effect of finance activity (FA) on GROWTH decreases as BERDIND increases. In other words, at higher levels of innovation or R&D adding more financial development reduces economic growth (see Figure 2.4). Again, comparing Figure 2.4 with Figure 2.2 or 2.3 suggest that the implications from the analysis of this sub-section and previous section remain unchanged.

Figure 2.3: Growth Effect of Finance Activity (FA) as BERDIND Changes (One-Step System GMM)

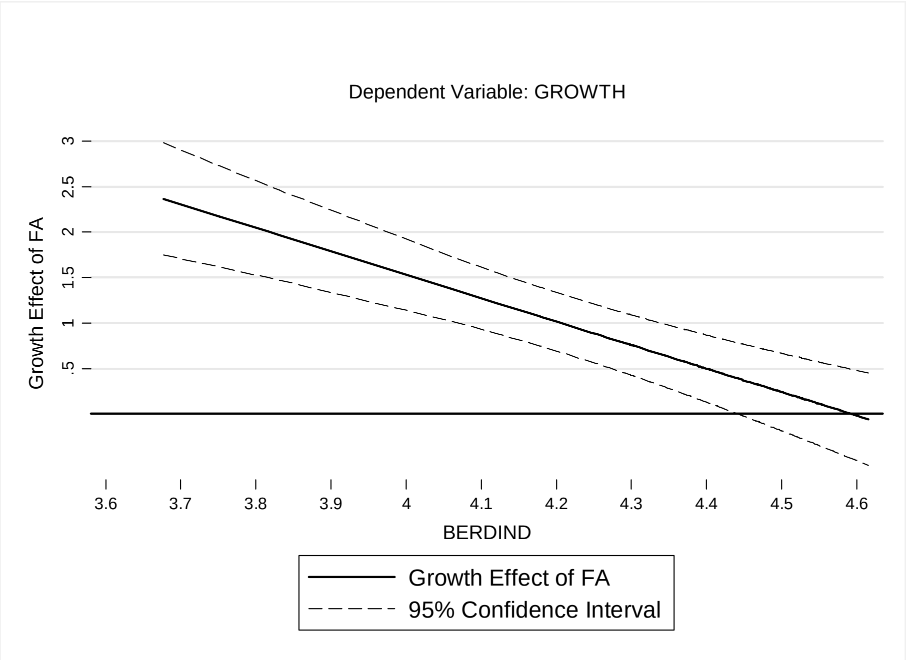


Table 2.4: Growth Effect of Finance Activity (FA) as Percentage of BERD Financed by Industry (BERDIND) Changes, Two-Way Fixed Effects

Two-Way Fixed Effects				
	(1)	(2)	(3)	(4)
VARIABLES	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers
LY0	-13.316*** (0.000)	-14.759*** (0.000)	-13.950*** (0.000)	-14.002*** (0.000)
HCBL	2.818 (0.616)	-2.567 (0.421)	-0.630 (0.908)	-3.941* (0.087)
INV	5.463*** (0.000)	5.154*** (0.000)	5.780*** (0.000)	5.389*** (0.000)
OPEN	1.491 (0.182)	2.110* (0.065)	2.240** (0.050)	2.487** (0.019)
GOV	-4.665 (0.119)	-1.895 (0.386)		
INF	-0.895*** (0.002)	-0.750*** (0.004)	-0.758*** (0.007)	-0.766*** (0.005)
FA	6.253*** (0.004)	6.276*** (0.000)	6.974*** (0.002)	6.801*** (0.000)
BERDIND	7.033* (0.090)	7.941** (0.011)	8.944** (0.025)	9.274*** (0.002)
FA*BERDIND	-1.384*** (0.005)	-1.368*** (0.001)	-1.562*** (0.002)	-1.476*** (0.000)
Time Dummies				
1986-1990	3.687** (0.025)	2.191** (0.033)	4.386*** (0.005)	3.904*** (0.004)
1991-1995	4.000** (0.024)	2.841** (0.016)	4.877*** (0.004)	4.455*** (0.002)
1996-2000	5.190*** (0.006)	4.096*** (0.003)	6.426*** (0.000)	5.654*** (0.000)
2001-2006	6.409*** (0.002)	5.448*** (0.000)	7.671*** (0.000)	6.784*** (0.000)
Constant	76.621** (0.033)	89.417*** (0.001)	63.616* (0.065)	69.804*** (0.006)
Observations	120	114	120	115
R-squared	0.837	0.908	0.828	0.899
Number of Countries	36	36	36	36
F-test for country effects (p-values)	0.000	0.000	0.000	0.000
F-test for time dummies (p-values)	0.001	0.000	0.000	0.000

Notes: As for Table 2.1. FA is finance activity. BERDIND is percent of BERD financed by industry. FA*BERDIND is interaction term between FA and BERDIND.

Table 2.5: Growth Effect of Finance Activity (FA) as Percentage of BERD Financed by Industry (BERDIND) Changes, One-Step Difference GMM

One-Step Difference GMM			
	(1)	(2)	(3)
VARIABLES	All Obs.	Excludes Outliers	All Obs.
LY0	-12.748*** (0.000)	-11.341*** (0.000)	-12.330*** (0.000)
HCBL	-3.172 (0.792)	-2.651 (0.816)	-9.780 (0.113)
INV	6.941*** (0.000)	6.158*** (0.001)	7.117*** (0.001)
OPEN	2.719 (0.282)	1.314 (0.589)	4.402* (0.080)
GOV	-4.880 (0.537)	-5.976 (0.437)	
INF	-0.981*** (0.004)	-1.062*** (0.003)	-0.915*** (0.006)
FA	8.228*** (0.009)	7.180** (0.035)	10.087*** (0.000)
BERDIND	6.450 (0.268)	3.535 (0.589)	8.571* (0.098)
FA*BERDIND	-1.918** (0.010)	-1.673** (0.038)	-2.380*** (0.000)
1986-1990	5.798** (0.038)	5.179* (0.067)	7.248*** (0.006)
1991-1995	6.776** (0.032)	5.891* (0.066)	8.460*** (0.003)
1996-2000	8.280** (0.024)	7.468** (0.046)	10.345*** (0.001)
2001-2006	9.706*** (0.009)	8.700** (0.022)	11.657*** (0.001)
Observations	84	83	84
Number of Countries	33	32	33
Number of instruments	31	31	28
F-Statistic (overall)	0.000	0.000	0.000
Hansen J-test (p-value)	0.24	0.33	0.36
Arellano-Bond AC(1) Test (p-value)	0.93	0.67	0.70
Arellano-Bond AC(2) Test (p-value)	0.87	0.72	0.43

Note: As for Table 2.2. FA is finance activity. BERDIND is percent of BERD financed by industry. FA*BERDIND is interaction term between FA and BERDIND.

Table 2.6: Growth Effect of Finance Activity (FA) as Percentage of BERD Financed by Industry (BERDIND) Changes, One-Step System GMM

	One-Step System GMM					
VARIABLES	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers
	(15)	(16)	(17)	(18)	(19)	(20)
LY0	-1.478 (0.227)	-1.336** (0.047)	-0.990 (0.474)	-0.858 (0.271)	-2.797** (0.047)	-2.748** (0.032)
HCBL	-1.326 (0.551)	-1.356 (0.310)	0.071 (0.975)	-0.024 (0.990)	-3.883 (0.116)	-2.038 (0.249)
INV	0.466 (0.847)	-1.004 (0.647)	1.702 (0.363)	0.839 (0.702)	-0.208 (0.924)	0.926 (0.690)
OPEN	-0.252 (0.872)	1.010 (0.236)				
GOV			-3.039 (0.282)	-2.562 (0.196)		
INF					-1.473* (0.090)	-1.323* (0.077)
FA	12.094*** (0.001)	11.857*** (0.000)	11.832*** (0.001)	13.320*** (0.000)	7.050 (0.176)	8.541** (0.020)
BERDIND	16.739*** (0.004)	13.858*** (0.000)	14.057** (0.019)	14.997*** (0.000)	10.645 (0.246)	11.486* (0.058)
FA*BERDIND	-2.625*** (0.002)	-2.582*** (0.000)	-2.550*** (0.003)	-2.874*** (0.000)	-1.514 (0.204)	-1.857** (0.028)
Time Dummies						
1986-1990	2.858 (0.351)	2.675* (0.057)	2.655 (0.145)	2.301 (0.172)	2.411 (0.329)	2.747 (0.159)
1991-1995	1.599 (0.622)	1.073 (0.462)	1.486 (0.409)	1.166 (0.535)	1.059 (0.693)	1.584 (0.449)
1996-2000	3.218 (0.426)	2.360 (0.144)	2.596 (0.234)	1.880 (0.391)	2.052 (0.535)	2.220 (0.383)
2001-2006	2.580 (0.561)	1.697 (0.347)	1.969 (0.400)	1.000 (0.668)	1.430 (0.653)	1.920 (0.439)
Constant	-60.993** (0.021)	-49.148*** (0.009)	-53.107** (0.027)	-56.735** (0.029)	-10.911 (0.822)	-23.107 (0.514)
Observations	123	107	125	119	122	118
Number of Countries	36	35	36	36	36	35
Number of instruments	33	33	33	33	33	33
F-Statistic (overall)	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J-test (p-value)	0.24	0.14	0.15	0.24	0.40	0.31
Arellano-Bond AC(1) Test (p-value)	0.14	0.02	0.09	0.01	0.20	0.05
Arellano-Bond AC(2) Test (p-value)	0.70	0.26	0.67	0.31	0.83	0.81

Notes: As for Table 2.3. FA is finance activity. BERDIND is percent of BERD financed by industry. FA*BERDIND is interaction term between FA and BERDIND.

Moreover, we repeat Tables 2.2, 2.3, 2.5 and 2.6 using corresponding two-step difference and system GMM estimation. These results are reported in Appendix A2, Tables A2.5-A2.8. These results are consistent with our earlier findings; however the significance of two measures of financial development (FS and FA), BERDIND and their interactions vary across models as well as Tables.

We also repeat the same analyses for a second measure of innovation or R&D, total number of applications per million of population (NPATA) and the two measures of financial development (FA and FS). These results are reported in Appendix A2, Tables A2.9 and A2.10. In most of the cases the coefficients on FS, FA and NPATA are positive and significant, whereas the interactions (FS*NPATA and FA*NPATA) are negative but insignificant. However, FS*NPATA is negative and significant in model (4), Table A2.9; while FA*NPATA is negative and significant in model (4), Table A2.10. Although these results are not as strong in terms of significance as those of Tables 2.1 to 2.6, they support those findings.

Overall, our results show that the marginal effects of financial development and R&D on economic growth are positive and significant, whereas their interaction has a negative and significant effect. It means the relationship between financial development and growth is not straight forward, rather it is conditional on the level of innovation or R&D. Further, it indicates that at a very high level of innovation or R&D, adding more financial development reduces its effect on economic growth; this can even be negative. Further, our diagnostic tests confirm that the instruments used in the analysis (except Table 2.1 and 2.4, where they are not required) are valid and that there is no second order serial correlation.

2.4.2. Summary Comparison

Table 2.7 shows a comparison of our regression estimates across three methods of estimation and two measures of financial development. In all models we include inflation (INF) as a control variable along with conditional variables because it appears as a significant variable in most of our results in Tables 2.1 through 2.6. In Table 2.7, models (1) through (3) report regression estimates from three alternate methods of estimation using finance size (FS) as a measure of financial development, whereas models (4) through (6) use finance activity (FA) as a measure of financial development.

In models (1) through (6) the coefficients of two measures of financial development (FS and FA) are positive and significant except model (5) where it is insignificant by a close margin (10.4%). Similarly, BERDIND is positive and significant in all cases, except models (2) and (5). However, the interactions between financial development variables and BERDIND are negative and significant in all the cases. We note that the coefficients on FS, FA and BERDIND obtained from one-step difference GMM and Two-way Fixed Effects are lower in magnitude as compared to the estimates obtained from one-step system GMM estimation; where, the estimates obtained from Two-way fixed effects lie between those obtained from one-step difference and system GMM methods. However, no such pattern is observed in case of the two interactions (FS*BERDIND and FA*BERDIND). We also note that our main estimates (FS, FA, BERDIND, FS*BERDIND and FA*BERDIND) obtained from one-step system GMM and Two-way fixed effects methods are very close in significance, whereas one-step GMM estimation renders FA and BERDIND insignificant.

Further, for robustness of our results we reproduce Table 2.7 using the number of patent applications per million of population as a measure of R&D (NPATA). These results are shown in Appendix A2, Tables A2.11. Although weak in significance, these results support our findings of Table 2.7. Overall, these results confirm that the effect of financial development on economic growth decreases as innovation increases and can even become negative at a very high level of innovation or R&D. Although negative effect is insignificant in our analysis, our investigation of these cases shows a mix of advanced and transitional economies that underwent high investment in R&D during different time periods to enhance their productivity growth.

Table 2.7: Growth Effects of Finance Size (FS) and Finance Activity (FA) as Percentage of BERD Financed by Industry (BERDIND) Changes; One-Step System GMM, One-Step Difference GMM, Two-Way Fixed Effects

Comparison Table						
	FS as a measure of FD			FA as a measure of FD		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	System GMM (One Step)	Difference GMM (One Step)	Two Way Fixed Effects	System GMM (One Step)	Difference GMM (One Step)	Two Way Fixed Effects
START	-2.904** (0.021)	-11.521*** (0.000)	-12.496*** (0.000)	-2.748** (0.032)	-11.125*** (0.001)	-12.325*** (0.000)
SCHOOLBL	-2.553 (0.313)	-7.894 (0.195)	1.911 (0.582)	-2.038 (0.249)	-10.090 (0.126)	0.417 (0.907)
INV	-1.314 (0.503)	2.671 (0.104)	4.298*** (0.002)	0.926 (0.690)	4.322** (0.017)	4.370*** (0.002)
INF	-0.800 (0.197)	-1.242*** (0.002)	-0.681** (0.019)	-1.323* (0.077)	-1.502*** (0.001)	-0.817*** (0.004)
FS	33.510*** (0.001)	19.111** (0.039)	19.840*** (0.001)			
FA				8.541** (0.020)	5.457 (0.104)	6.404*** (0.001)
BERDIND	33.174*** (0.004)	14.739 (0.232)	18.444*** (0.005)	11.486* (0.058)	0.877 (0.911)	8.116** (0.014)
FS*BERDIND	-7.319*** (0.002)	-4.432** (0.042)	-4.356*** (0.002)			
FA*BERDIND				-1.857** (0.028)	-1.279* (0.100)	-1.403*** (0.001)
Constant	-114.005** (0.040)		15.736 (0.664)	-23.107 (0.514)		64.202** (0.018)
Observations	117	80	117	118	82	118
R-squared			0.807			0.814
Number of countries	35	32	35	35	33	35
Number of Instruments	33	25		33	25	
F-Statistic (overall)	0.000	0.000		0.000	0.000	
Hansen J-test (p-value)	0.26	0.23		0.31	0.30	
Arellano-Bond AC(1) test (p-value)	0.07	0.30		0.05	0.32	
Arellano-Bond AC(2) test (p-value)	0.92	0.26		0.81	0.42	

Notes: As for Tables 2.1-2.6. Models (1)-(3) exclude outliers identified in model (1). Similarly models (4)-(6) exclude outlying observations found in model (4).

2.5. Conclusion

This chapter investigates the conditional effects of financial development on economic growth, using innovation or R&D as a conditioning variable. In the light of the recent literature that associates R&D with financial innovation that may be poorly regulated (see Gennaioli et al, 2010; Michalopoulos et al, 2010; Ductor and Grechyna, 2011), we use this variable as a proxy and study its interaction with conventionally measured financial development. Our aim is to combine financial development, innovation and growth through two testable hypotheses: first, the relationship between financial development and economic growth is not straightforward, rather it is conditional upon the level of innovation or R&D; and second, a high level of technological innovation or R&D is associated with a weak or negative effect of financial development on economic growth.

We employ two measures of financial sector development: finance size (FS) and finance activity (FA), and two measures of R&D activity: R&D intensity (BERDIND) and the number of patent applications (NPATA). Further, we use a multiplicative interaction model to capture the conditional effects of financial development on growth which is estimated by employing three estimation techniques of panel data: two-way fixed effects, difference GMM, and system GMM estimators that take into account the problem of endogeneity and country specific characteristics. We take care of influential outliers by applying the *Hampel Identifier* to the residuals obtained from each model.

Our regression results show that the marginal effects of financial development and R&D on economic growth are positive and significant. Further, the relationship between financial development and growth is conditional upon the level of R&D; that is, it decreases as the level of R&D increases and even becomes negative at very high levels of R&D. Thus, the negative interaction between financial development and R&D suggests that at a very high level of R&D adding more financial development may not be a growth promoting policy.

We provide two explanations for these findings: first, countries with a very high level of innovation or R&D activities may have highly deregulated financial systems that promote financial innovations to meet the demands of innovators or investors. In this situation adding more financial development is likely to deteriorate credit standards, increase growth of non-performing loans, generate credit booms and increase the probability of bank crises. Consequently, financial crises have an adverse impact on economic growth. In this sense our findings are consistent with the most recent literature (Michalopoulos et al, 2010; Rousseau and Wachtel, 2011). Second, as the sign of our interaction terms is negative it suggests that financial development and innovation are substitutes. Hence growth promoting policies should be directed either to financial sector development or innovation sector. In this sense our results are consistent with the view that any subsidy given to either of the financial and innovation sector is better than if it is given to both (see Morales, 2003). Our study proposes that financial development is more effective in those countries whose investment in R&D, especially industrial R&D, is low. This may be an indication, though not a direct proof, that countries which have high R&D (e.g. Japan, Korea, Turkey, Switzerland, Luxembourg, Finland, etc) may be those where the financial systems are less regulated, specifically in relation to financial innovations, which may cause conventionally measured financial development to loose its effectiveness to promote growth in the economy. This could be an agenda for future research.

Appendix A2

Table A2.1: List of countries

This table contains the list of countries used in the analysis.

	Country	Income Group		Country	Income Group
1	Argentina	Upper middle income	19	Mexico	Upper middle income
2	Australia	High income: OECD	20	Netherlands	High income: OECD
3	Austria	High income: OECD	21	New Zealand	High income: OECD
4	Belgium	High income: OECD	22	Norway	High income: OECD
5	Canada	High income: OECD	23	Poland	Upper middle income
6	Czech Rep.	High income: OECD	24	Portugal	High income: OECD
7	Denmark	High income: OECD	25	Romania	Upper middle income
8	Finland	High income: OECD	26	Russian Fed.	Upper middle income
9	France	High income: OECD	27	Singapore	High income: non-OECD
10	Germany	High income: OECD	28	Slovak Rep.	High income: OECD
11	Greece	High income: OECD	29	Slovenia	High income: non-OECD
12	Hungary	High income: OECD	30	South Africa	Upper middle income
13	Iceland	High income: OECD	31	Spain	High income: OECD
14	Ireland	High income: OECD	32	Sweden	High income: OECD
15	Israel	High income: non-OECD	33	Switzerland	High income: OECD
16	Italy	High income: OECD	34	Turkey	Upper middle income
17	Japan	High income: OECD	35	United Kingdom	High income: OECD
18	Korea, Rep.	High income: OECD	36	United States	High income: OECD

Table A2.2: Definitions and Sources of Variables used in the Analysis

Variable	Definition and Construction	Source
Real per capita GDP growth (**GROWTH**)	Log difference of real per capita GDP	Author's construction using data from World Development Indicators (WDI), World Bank
Initial real per capita GDP (**LY0**)	Log of Initial value of real per capita GDP	WDI, World Bank
Average years of schooling (**HCBL**)	Educational Attainment of the Total Population Aged 25 and Over. Calculated as log of (1+average years of schooling)	Author's construction using data from Barro and Lee, 2010.
Finance Activity (**FA**)	Measures the overall activity in the financial sector and is constructed as the log of the product of Private Credit (value of private credit by deposit money banks as percentage of GDP) and Trading Value (value of the total shares traded at stock exchanges as percentage of GDP ratio).	Author's construction using data from "A New Database on Financial Development and Structure (updated Nov. 2008), World Bank".
Finance Size (**FS**)	Measures the overall size of the financial sector and is constructed as the log of the sum of Private Credit and Market Capitalization (value of listed shares as percentage of GDP ratio)	Author's construction using data from "A New Database on Financial Development and Structure (updated Nov. 2008), World Bank".
Percentage of BERD financed by industry (**BERDIND**)	Measures both innovation and imitating activities and is equal to the log of percentage of Business Enterprise Expenditures on R&D (BERD) financed by industry.	Author's construction using data from OECD-Main Science and Technology Indicators (MSTI), 2008.
Number of patent applications (**NPATA**)	Measures innovation activities only and is equal to the log of number of patent applications per million of population	Author's construction using data from OECD-Main Science and Technology Indicators (MSTI), 2008.
Investment (**INV**)	Log of gross fixed capital formation as percentage of GDP	WDI, World Bank
Openness (**OPEN**)	Log of exports plus imports as percentage of GDP	WDI, World Bank
Government Size (**GOV**)	Log of general government final consumption expenditures as percentage of GDP	WDI, World Bank
Inflation (**INF**)	Percentage change in consumer price index	WDI, World Bank

Table A2.3: Summary Statistics and Correlations

Variable	N	Mean	Median	SD	Min	Max
GROWTH	183	2.1608	1.9849	2.3703	-9.5022	10.3767
LY0	181	9.2988	9.6534	0.9762	5.2281	10.7424
HCBL	182	2.2105	2.2695	0.2466	1.3634	2.5839
FA	142	6.6281	6.8509	2.2224	-1.4857	10.4676
FS	143	4.5755	4.6374	0.7811	2.1447	5.9914
BERDIND	156	4.4228	4.4611	0.1526	3.6771	4.6151
NPATA	174	2.7086	3.4484	2.2560	-3.4901	5.9129
FA*BERDIND	129	30.1571	30.7492	9.5526	-1.2809	47.3198
FS*BERDIND	130	20.4033	20.6198	3.4795	8.2162	27.085
INV	185	3.0930	3.0705	0.1965	2.7032	3.8236
OPEN	177	4.1285	4.1325	0.5602	2.7113	6.0202
GOV	182	2.8555	2.9266	0.3079	1.4267	3.6355
INF	175	1.7366	1.4955	1.3195	-1.1841	7.0830

Table A2.3: Continued

Correlation

	GROWTH	LY0	HCBL	FA	FS	BERDIND	NPATA	FA* BERDIND	FS* BERDIND	INV	OPEN	GOV	INF
GROWTH	1.0000												
LY0	-0.2003	1.0000											
HCBL	-0.1350	0.4846	1.0000										
FA	0.2478	0.5918	0.4302	1.0000									
FS	0.1865	0.7010	0.3372	0.8286	1.0000								
BERDIND	0.1131	0.3294	-0.1855	0.2269	0.3038	1.0000							
NPATA	-0.0333	0.8656	0.5823	0.6794	0.7388	0.2109	1.0000						
FA*BERDIND	0.2678	0.6276	0.3440	0.9959	0.8515	0.3021	0.6770	1.0000					
FS*BERDIND	0.1887	0.7726	0.2628	0.8317	0.9854	0.4560	0.7339	0.8467	1.0000				
INV	0.3297	-0.2387	-0.2234	0.0948	0.0807	0.3127	-0.1648	0.0610	0.1285	1.0000			
OPEN	0.1527	0.1530	0.1409	0.0088	0.1501	0.0132	0.1992	-0.0535	0.0256	-0.0380	1.0000		
GOV	-0.1260	0.3430	0.3120	0.2463	0.2769	-0.0694	0.4452	0.1551	0.1438	-0.3300	0.2541	1.0000	
INF	-0.3450	-0.5437	-0.3360	-0.7163	-0.7993	-0.3660	-0.7327	-0.7279	-0.8050	-0.0757	-0.2601	-0.2657	1.0000

Table A2.4: List of Excluded Outlier Observations

Tables 2.1 through 2.7 and A2.5 through A2.11 contain models that exclude outlier observations from their analysis using an ad hoc measure of *Hampel Identifier*. Following is the list of excluded outlier observations from that analysis.

Table 2.1	
Model (2)	Italy 1905; Norway 1902; Slovak Republic 1903, 1905.
Model (4)	Ireland 1903; Italy 1905; Norway 1902; Slovak Republic 1903, 1905.
Table 2.2	
Model (2)	Romania 1904.
Model (4)	NA
Table 2.3	
Model (2)	Ireland 1904; Korea, Rep. 1903; Norway 1903; Romania 1905; Slovak Republic 1903; South Africa 1905.
Model (4)	Hungary 1903; Ireland 1904; Mexico 1902, 1903; New Zealand 1902; Slovak Republic 1903; South Africa 1905.
Model (6)	Ireland 1904; Norway 1903; Portugal 1905; Romania 1905, Slovak Republic 1903, South Africa 1905.
Table 2.4	
Model (2)	Ireland 1903; Italy 1905; Norway 1902; Portugal 1901; Slovak Republic 1903, 1905.
Model (4)	Ireland 1903; Italy 1905; Norway 1902; Slovak Republic 1903, 1905.
Table 2.5	
Model (2)	Romania 1904, 1905.
Model (4)	NA
Table 2.6	
Model (2)	Czech Republic 1903; Hungary 1903; Ireland 1903,1904; Italy 1905; Korea 1903; Mexico 1902, 1903; Norway 1903; Portugal 1905; Romania 1905; Slovak Republic 1903, 1905; South Africa 1905; Turkey 1904; United Kingdom 1905.
Model (4)	Ireland 1904; Mexico 1902, 1903; Romania 1905; Slovak Republic 1903, 1905.
Model (6)	Ireland 1904; Portugal 1905; Slovak Republic 1903; South Africa 1905.
Table 2.7	
Model (1)	Ireland 1904; Norway 1903; Portugal 1905; Romania 1905; Slovak Republic 1903; South Africa 1905.
Model (2)	NA
Model (3)	NA
Model (4)	Ireland 1904; Portugal 1905; Slovak Republic 1903; South Africa 1905.
Model (5)	NA
Model (6)	NA
Table A2.5	
Model (2)	Romania 1904.
Model (4)	NA
Table A2.6	
Model (2)	Czech Republic 1903; Hungary 1903; Ireland 1904; Korea 1903; Mexico 1902, 1903; New Zealand 1902; Norway 1903; Portugal 1905; Romania 1905; Slovak Republic 1903; South Africa 1905; Turkey 1904.
Model (4)	Hungary 1903; Ireland 1904; Mexico 1902, 1903; New Zealand 1902; Slovak Republic 1903; South Africa 1905.
Model (6)	Portugal 1905; Slovak Republic 1903; South Africa 1905.
Table A2.7	
Model (2)	Romania 1904.
Model (4)	NA
Table A2.8	
Model (2)	Ireland 1904; Korea 1903; Mexico 1902; Norway 1903; Romania 1905; Slovak Republic 1903, 1905; United Kingdom 1905.
Model (4)	Ireland 1904; Mexico 1902, 1903; Romania 1905; Slovak Republic 1905.

Model (6)	Ireland 1904; Portugal 1905; Slovak Republic 1903; South Africa 1905.
Table A2.9	
Model (2)	Czech Republic 1903, 1904; Ireland 1904; Korea 1903; Mexico 1901; New Zealand 1902; Norway 1903; Poland 1903, 1904; Portugal 1901, 1905; Romania 1905; Russian Federation 1903; Slovak Republic 1903; South Africa 1902, 1903, 1904, 1905.
Model (4)	Hungary 1903, 1904; Norway 1903; Poland 1903, 1904; Portugal 1901; Russian Federation 1903; South Africa 1902, 1903, 1904.
Model (6)	Korea 1901, 1902; Poland 1903, 1904; Portugal 1901, 1905; Romania 1905; Russian Federation 1903; South Africa 1902, 1903, 1904, 1905.
Table A2.10	
Model (2)	Argentina 1905; Romania 1905; South Africa 1902-1904.
Model (4)	Norway 1903; Poland 1903; South Africa 1902-1904.
Model (6)	South Africa 1902, 1903.
Table 2.7	
Model (1)	Korea 1901, 1902; Poland 1903, 1904; Portugal 1901, 1905; Romania 1905; South Africa 1902-1904.
Model (2)	NA
Model (3)	NA
Model (4)	South Africa 1902, 1903.
Model (5)	NA
Model (6)	NA
Note: Five year averages over the period 1981-2006: 1981-1985, 1986-1990, 1991-1995, 1996-2000, and 2001-2006 are shown by 1901, 1902, 1903, 1904, and 1905 respectively.	

Table A2.5: Growth Effect of Finance Size (FS) as Percentage of BERD Financed by Industry (BERDIND) Changes, Two-Step Difference GMM

Two-Step Difference GMM			
	(1)	(2)	(3)
VARIABLES	All Obs.	Excludes Outliers	All Obs.
LY0	-12.734*** (0.000)	-12.156*** (0.000)	-12.465*** (0.000)
HCBL	-5.739 (0.772)	-5.202 (0.752)	-10.765 (0.173)
INV	5.208*** (0.002)	4.767*** (0.001)	5.258*** (0.000)
OPEN	3.564 (0.424)	2.774 (0.394)	6.057* (0.062)
GOV	-2.613 (0.759)	-3.767 (0.616)	
INF	-0.830 (0.137)	-0.862* (0.094)	-0.852* (0.077)
FS	24.256** (0.038)	21.938* (0.064)	28.406*** (0.000)
BERDIND	18.707 (0.178)	15.414 (0.242)	21.168* (0.062)
FS*BERDIND	-5.457* (0.056)	-4.976* (0.076)	-6.551*** (0.000)
Time Dummies			
1986-1990	4.644* (0.065)	4.364 (0.101)	4.972** (0.020)
1991-1995	5.400* (0.065)	4.987* (0.093)	5.702** (0.011)
1996-2000	6.740* (0.061)	6.446* (0.071)	7.150*** (0.003)
2001-2006	7.784** (0.031)	7.570** (0.037)	8.108*** (0.002)
Observations	85	84	85
Number of Countries	33	32	33
Number of instruments	31	31	28
F-Statistic (overall)	0.000	0.000	0.000
Hansen J-test (p-value)	0.18	0.21	0.24
Arellano-Bond AC(1) Test (p-value)	0.90	0.82	0.95
Arellano-Bond AC(2) Test (p-value)	0.88	0.69	0.99
Notes: As for Table 2.2.			

Table A2.6: Growth Effect of Finance Size (FS) as Percentage of BERD Financed by Industry (BERDIND) Changes, Two-Step System GMM

Two-Step System GMM						
	(23)	(24)	(25)	(26)	(27)	(28)
VARIABLES	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers
LY0	-2.941 (0.175)	-3.150* (0.074)	-2.202 (0.312)	-2.000 (0.303)	-3.516** (0.012)	-2.549* (0.099)
HCBL	-1.261 (0.732)	-1.660 (0.592)	2.353 (0.708)	-0.053 (0.988)	-4.642 (0.228)	-2.619 (0.657)
INV	-2.263 (0.516)	-1.814 (0.462)	-0.669 (0.738)	-1.956 (0.512)	-2.238 (0.421)	-1.398 (0.687)
OPEN	-0.354 (0.823)	1.061 (0.499)				
GOV			-3.876 (0.424)	-4.562 (0.138)		
INF					-0.803 (0.269)	-0.883 (0.436)
FS	37.146** (0.018)	34.459*** (0.009)	35.715* (0.053)	36.837*** (0.000)	19.374 (0.275)	31.679 (0.198)
BERDIND	35.940** (0.045)	31.547*** (0.005)	31.223* (0.100)	31.919*** (0.004)	18.106 (0.418)	32.599 (0.397)
FS*BERDIND	-7.794** (0.033)	-7.309** (0.017)	-7.498 (0.105)	-7.808*** (0.002)	-3.703 (0.356)	-6.942 (0.232)
Time Dummies						
1986-1990	3.554* (0.064)	3.927 (0.124)	2.979* (0.079)	3.809*** (0.003)	3.359* (0.059)	3.197 (0.126)
1991-1995	1.781 (0.385)	2.266 (0.399)	1.363 (0.455)	2.375* (0.067)	1.650 (0.413)	1.990 (0.487)
1996-2000	3.306 (0.104)	3.248 (0.183)	2.518 (0.143)	2.993** (0.044)	2.622 (0.249)	3.401 (0.315)
2001-2006	2.202 (0.300)	2.305 (0.377)	1.536 (0.345)	2.155 (0.182)	1.624 (0.405)	2.670 (0.377)
Constant	-132.378* (0.086)	-114.818** (0.023)	-120.722 (0.192)	-113.784** (0.026)	-42.018 (0.681)	-113.353 (0.525)
Observations	124	111	126	119	123	120
Number of Countries	36	35	36	35	36	35
Number of instruments	33	33	33	33	33	33
F-Statistic (overall)	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J-test (p-value)	0.28	0.15	0.12	0.11	0.24	0.11
Arellano-Bond AC(1) Test (p-value)	0.43	0.02	0.29	0.05	0.34	0.13
Arellano-Bond AC(2) Test (p-value)	0.64	0.64	0.55	0.63	0.55	0.73

Notes: As for Table 2.3.

Table A2.7: Growth Effect of Finance Activity (FA) as Percentage of BERD Financed by Industry (BERDIND) Changes, Two-Step Difference GMM

Two-Step Difference GMM			
	(1)	(2)	(3)
VARIABLES	All Obs.	Excludes Outliers	All Obs.
LY0	-12.932*** (0.000)	-11.604*** (0.001)	-14.025*** (0.000)
HCBL	-7.346 (0.653)	-7.615 (0.561)	-9.841 (0.431)
INV	6.681*** (0.002)	5.943*** (0.004)	6.566** (0.018)
OPEN	2.786 (0.461)	1.778 (0.565)	5.933* (0.080)
GOV	-1.873 (0.844)	-2.896 (0.699)	
INF	-1.022** (0.044)	-0.970** (0.041)	-0.956** (0.035)
FA	9.320** (0.046)	9.416** (0.035)	11.026*** (0.000)
BERDIND	8.328 (0.282)	7.275 (0.393)	11.560** (0.030)
FA*BERDIND	-2.207* (0.054)	-2.221** (0.048)	-2.663*** (0.000)
Time Dummies			
1986-1990	7.387 (0.101)	6.979 (0.132)	9.340** (0.013)
1991-1995	8.777* (0.079)	8.269 (0.112)	10.763** (0.011)
1996-2000	10.715* (0.067)	10.295* (0.085)	12.985*** (0.006)
2001-2006	12.168** (0.041)	11.583* (0.063)	14.506*** (0.003)
Observations	84	83	84
Number of Countries	33	32	33
Number of instruments	31	31	28
F-Statistic (overall)	0.000	0.000	0.000
Hansen J-test (p-value)	0.24	0.33	0.36
Arellano-Bond AC(1) Test (p-value)	0.68	0.89	0.20
Arellano-Bond AC(2) Test (p-value)	0.59	0.84	0.60
Notes: As for Table 2.5.			

Table A2.8: Growth Effect of Finance Activity (FA) as Percentage of BERD Financed by Industry (BERDIND) Changes, Two-Step System GMM

Two-Step System GMM						
	(23)	(24)	(25)	(26)	(27)	(28)
VARIABLES	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers
LY0	-1.369 (0.333)	-0.536 (0.708)	-0.616 (0.792)	-0.447 (0.706)	-2.854* (0.051)	-3.149** (0.026)
HCBL	-2.603 (0.293)	-0.702 (0.668)	-0.809 (0.807)	-1.904 (0.500)	-4.018 (0.198)	-3.110 (0.158)
INV	-0.466 (0.905)	0.420 (0.924)	0.828 (0.769)	1.877 (0.410)	0.318 (0.892)	0.781 (0.707)
OPEN	-0.050 (0.975)	1.003 (0.406)				
GOV			-3.395 (0.431)	-1.508 (0.619)		
INF					-1.628* (0.064)	-1.638* (0.051)
FA	12.843*** (0.001)	11.732*** (0.005)	12.956*** (0.003)	14.481*** (0.000)	6.110 (0.151)	8.094* (0.055)
BERDIND	16.189*** (0.008)	11.572* (0.054)	14.162* (0.055)	15.884** (0.019)	8.384 (0.459)	11.664* (0.076)
FA*BERDIND	-2.786*** (0.001)	-2.568*** (0.010)	-2.820*** (0.008)	-3.158*** (0.000)	-1.305 (0.178)	-1.770* (0.064)
Time Dummies						
1986-1990	2.849 (0.323)	2.273 (0.436)	3.060 (0.326)	3.102 (0.147)	2.206 (0.384)	3.063 (0.144)
1991-1995	1.351 (0.660)	0.653 (0.834)	1.665 (0.609)	2.050 (0.391)	0.522 (0.852)	1.710 (0.478)
1996-2000	2.978 (0.454)	2.089 (0.567)	3.128 (0.403)	3.232 (0.235)	1.545 (0.630)	2.340 (0.392)
2001-2006	2.211 (0.615)	1.152 (0.774)	2.288 (0.573)	2.160 (0.440)	0.892 (0.775)	2.036 (0.458)
Constant	-54.633** (0.025)	-51.776* (0.068)	-51.206* (0.080)	-66.970** (0.043)	-0.917 (0.986)	-16.555 (0.665)
Observations	123	115	125	120	122	118
Number of Countries	36	36	36	36	36	35
Number of instruments	33	33	33	33	33	33
F-Statistic (overall)	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J-test (p-value)	0.24	0.14	0.15	0.27	0.40	0.31
Arellano-Bond AC(1) Test (p-value)	0.32	0.07	0.29	0.02	0.22	0.08
Arellano-Bond AC(2) Test (p-value)	0.75	0.14	0.70	0.35	0.91	0.79

Notes: As for Table 2.6.

Table A2.9: Growth Effect of Finance Size (FS) as Number of Patent Applications per Million of Population (NPATA) Changes, One-Step System GMM

One-Step System GMM						
	(15)	(16)	(17)	(18)	(19)	(20)
VARIABLES	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers
LY0	-1.453 (0.671)	0.615 (0.734)	-4.191* (0.053)	-4.475* (0.064)	-2.885 (0.482)	-8.321*** (0.001)
HCBL	-1.777 (0.804)	0.216 (0.929)	-6.485 (0.186)	-4.650 (0.315)	-10.612* (0.057)	-15.930*** (0.003)
INV	1.189 (0.710)	4.616 (0.155)	2.081 (0.499)	0.458 (0.890)	-0.425 (0.865)	-0.111 (0.970)
OPEN	1.120 (0.379)	0.181 (0.890)				
GOV			-5.625* (0.081)	-5.137* (0.057)		
INF					0.313 (0.694)	-0.394 (0.694)
FS	4.007** (0.014)	0.717 (0.631)	2.507 (0.145)	2.372 (0.164)	3.364** (0.030)	3.912** (0.044)
NPATA	2.972** (0.025)	0.694 (0.620)	4.488*** (0.009)	3.809** (0.010)	5.034** (0.027)	3.617 (0.139)
FS*NPATA	-0.710 (0.104)	-0.225 (0.470)	-0.604 (0.124)	-0.475* (0.093)	-0.851 (0.205)	-0.200 (0.710)
Time Dummies						
1986-1990	0.312 (0.882)	1.216 (0.405)	-0.779 (0.715)	-2.251 (0.154)	-0.411 (0.867)	-2.931 (0.153)
1991-1995	-1.371 (0.562)	-0.203 (0.897)	-1.723 (0.480)	-3.564** (0.038)	-1.548 (0.569)	-3.961* (0.085)
1996-2000	0.401 (0.851)	1.626 (0.343)	-0.503 (0.827)	-2.575 (0.150)	0.624 (0.810)	-3.680 (0.107)
2001-2006	-0.242 (0.909)	1.284 (0.463)	-0.729 (0.756)	-2.993 (0.135)	0.292 (0.914)	-4.201* (0.080)
Constant	-5.112 (0.916)	-22.154 (0.432)	50.828 (0.110)	55.900* (0.081)	36.358 (0.445)	95.579*** (0.001)
Observations	130	112	132	122	129	118
Number of Countries	36	35	36	36	36	35
Number of instruments	33	33	33	33	33	33
F-Statistic (overall)	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J-test (p-value)	0.45	0.14	0.76	0.36	0.41	0.79
Arellano-Bond AC(1) Test (p-value)	0.28	0.17	0.97	0.31	0.43	0.42
Arellano-Bond AC(2) Test (p-value)	0.56	0.65	0.32	0.50	0.33	0.63

Notes: As for Table 2.3. NPATA is the number of patent applications per million of population. FS* NPATA is interaction term between FS and NPATA.

Table A2.10: Growth Effect of Finance Activity (FA) as Number of Patent Applications per Million of Population (NPATA) Changes, One-Step System GMM

One-Step System GMM						
	(15)	(16)	(17)	(18)	(19)	(20)
VARIABLES	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers	All Obs.	Excludes Outliers
LY0	-3.766 (0.226)	-3.534 (0.168)	-4.751* (0.078)	-4.153** (0.041)	-5.858* (0.083)	-6.858*** (0.009)
HCBL	-4.504 (0.402)	-5.054 (0.208)	-6.525 (0.220)	-2.724 (0.624)	-11.072*** (0.010)	-11.019*** (0.005)
INV	0.373 (0.928)	-1.898 (0.464)	1.961 (0.596)	-0.524 (0.863)	2.822 (0.400)	1.981 (0.504)
OPEN	1.444 (0.350)	0.335 (0.751)				
GOV			-3.893 (0.224)	-5.233** (0.037)		
INF					-0.777 (0.468)	-1.668 (0.111)
FA	1.386*** (0.005)	1.347*** (0.003)	1.125** (0.046)	1.312*** (0.002)	0.799 (0.165)	0.713 (0.161)
NPATA	2.204*** (0.008)	1.854** (0.024)	3.506*** (0.000)	3.453*** (0.000)	3.018** (0.021)	1.638 (0.194)
FA*NPATA	-0.192 (0.186)	-0.144 (0.288)	-0.232 (0.140)	-0.294** (0.041)	-0.128 (0.558)	0.034 (0.835)
Time Dummies						
1986-1990	-4.411** (0.044)	-3.878** (0.030)	-4.644* (0.067)	-5.509*** (0.007)	-3.054 (0.305)	-1.251 (0.620)
1991-1995	-6.129** (0.014)	-5.826*** (0.004)	-5.778** (0.042)	-7.410*** (0.001)	-4.050 (0.194)	-2.603 (0.336)
1996-2000	-5.349** (0.048)	-4.852** (0.022)	-4.959* (0.096)	-6.311*** (0.003)	-3.460 (0.241)	-3.068 (0.228)
2001-2006	-5.908** (0.034)	-5.772*** (0.008)	-5.129* (0.095)	-6.590*** (0.002)	-3.720 (0.220)	-3.648 (0.160)
Constant	34.444 (0.441)	45.103 (0.147)	59.029* (0.077)	58.080** (0.045)	66.713 (0.110)	80.197*** (0.005)
Observations	129	123	131	126	128	126
Number of Countries	36	35	36	36	36	36
Number of instruments	33	33	33	33	33	33
F-Statistic (overall)	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J-test (p-value)	0.41	0.69	0.48	0.29	0.32	0.41
Arellano-Bond AC(1) Test (p-value)	0.37	0.25	0.59	0.25	0.87	0.40
Arellano-Bond AC(2) Test (p-value)	0.45	0.52	0.31	0.22	0.45	0.33

Notes: As for Table 2.6. NPATA is the number of patent applications per million of population. FA * NPATA is interaction term between FA and NPATA.

Table A2.11: Growth Effect of Finance Size (FS) and Finance Activity (FA) as Number of Patent Applications per Million of Population (NPATA) Changes; One-Step System GMM, One-Step Difference GMM, Two Way Fixed Effects

Comparison Table						
	FS as a measure of FD			FA as a measure of FD		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	System GMM (One Step)	Difference GMM (One Step)	Two Way Fixed Effects	System GMM (One Step)	Difference GMM (One Step)	Two Way Fixed Effects
LY0	-8.321*** (0.001)	-12.395*** (0.007)	-16.056*** (0.000)	-6.858*** (0.009)	-14.455*** (0.001)	-14.019*** (0.000)
HCBL	-15.930*** (0.003)	-16.223* (0.055)	-3.688 (0.438)	-11.019*** (0.005)	-16.529 (0.100)	-5.501 (0.220)
INV	-0.111 (0.970)	3.057 (0.202)	2.224* (0.090)	1.981 (0.504)	3.479* (0.053)	2.978* (0.059)
INF	-0.394 (0.694)	-0.317 (0.679)	-0.289 (0.357)	-1.668 (0.111)	0.336 (0.577)	-0.401 (0.233)
FS	3.912** (0.044)	2.502** (0.019)	1.312 (0.165)			
FA				0.713 (0.161)	0.843* (0.086)	0.487* (0.081)
NPATA	3.617 (0.139)	4.705*** (0.004)	2.344** (0.021)	1.638 (0.194)	3.930*** (0.000)	2.538*** (0.000)
FS*NPATA	-0.200 (0.710)	-0.542 (0.126)	-0.156 (0.431)			
FA*NPATA				0.034 (0.835)	-0.220* (0.050)	-0.069 (0.302)
Constant	95.579*** (0.001)		146.272*** (0.000)	80.197*** (0.005)		129.056*** (0.000)
Observations	118	83	118	126	90	126
R-squared			0.811			0.790
Number of Countries	35	32	35	36	35	36

Notes: As for Table 2.7. NPATA is number of patent applications per million of population. FS*NPATA is interaction term between FS and NPATA, FA*NPATA is interaction term between FA and NPATA.

Chapter 3

Inequality and the Process of Economic Growth: Threshold Effects of Human Capital to Physical Capital Ratio

3.1. Introduction

Greenwood and Jovanovic (1990) is a pioneer study that combines the two prominent strands of literature on growth and development: the link between financial development and growth, and the relationship between income inequality and growth. They predict a non-linear relationship between financial development, income inequality and economic growth, and show that at the early stage of economic development, the financial systems are less developed and only the rich class benefit from it. Consequently, growth increases at the cost of increased inequality across the rich and the poor. However, in the latter stage of development, as the financial intermediaries expand and many people join them, income inequality decreases and economic growth increases at a faster rate than the early stage of development. In this chapter, rather than investigating the direct role of financial development for the effect of income inequality on growth as implied by Greenwood and Jovanovic (1990), we explore the indirect role of financial sector development through its effect on human capital development as implied by Galor and Moav (2004).

An enormous theoretical and empirical literature has been devoted to the nature and extent of the relationship between inequality and growth. This literature can be divided into three broad categories or approaches: First, the *classical approach* according to which high initial income inequality channels resources towards those who already have higher marginal propensity to save and thereby increases the aggregate saving, physical capital accumulation and growth (see Smith, 1776; Keynes, 1920; Lewis, 1954; Kaldor, 1955, 1957; Bourguignon, 1981). Second, the *modern approach*[26] which, opposite to the classical approach, explains that equality alleviates the adverse effects of credit constraints on investment in human capital and thereby enhances economic growth (see Galor and Zeira, 1993; Alesina and Rodrik, 1994; Persson and Tabellini, 1994). Third, the *unified approach* provides the intertemporal reconciliation between the above two contrasting approaches. It argues that a classical approach reflects the early stage of development, whereas the modern approach reflects the later stage of development (see Galor, 2000; Galor and Moav, 2004).

In the context of the classical approach, the pioneer empirical work is Kuznets (1955) who started a continuing debate on the relationship between inequality and economic development or growth. He argues that causality runs from economic development to inequality and stresses the inverted U-shaped relationship between inequality and growth famously known as the Kuznets Hypothesis, where initially inequality increases and then decreases with economic development. Subsequent studies, mostly based on cross-sectional analysis due to the shortage of time series data for developing countries, try to test and verify the inverted U-shaped relationship of the Kuznets Hypothesis and come up with mixed results (see Ahluwalia, 1976; Ram, 1988; Anand and Kanbur, 1993; Aghion and Bolton, 1997; Deininger and Squire, 1998; Barro, 2000; Lopez, 2006; Huang et al, 2009). These mixed results may be mainly due to the problems related to the quality of data, econometric methodology, and model specification.

The second and third approaches are based on carefully crafted theoretical models that try to identify the channels through which inequality may affect economic growth, such as credit market imperfections, majority rule (political) and technological innovation etc. In this context, Galor and Zeira (1993) is a prominent theoretical study that analyses the role of income distribution in economic development through investment in human capital, credit markets being imperfect. They show that the initial distribution of wealth affects aggregate output and investment in the short run as well as in the long run because of multiple steady states. However, the theoretical work of Alesina and Rodrik (1994) and Persson and

[26] Also known as 'Capital Market Imperfection Approach'. It combines the credit market imperfection approach of Galor and Ziera (1993), political approach of Alesina and Rodrik (1994), and other related approaches (see Galor, 2000; Galor and Moav, 2004; Iradian, 2005).

Tabellini (1994) suggest a negative effect of inequality on economic growth. Empirical work again gives mixed results, where some studies suggest a positive effect of inequality on growth, while others show a negative effect and 'inverse U-shape' relationship (see Bandyopadhyay and Basu, 2005; Partridge, 1997; Li and Zou, 1998; Deininger and Squire, 1998; Barro, 2000; Forbes, 2000; Panizza, 2002; Chen, 2003; Huang, 2004; Voitchovsky, 2005; Huang et al, 2009; Lin et al, 2009; Chambers and Krause, 2010).

Galor (2000) and Galor and Moav (2004) are remarkable theoretical studies that combine the first two approaches and develop a unified framework to analyse the effect of inequality on economic growth. They argue that human capital accumulation replaces, endogenously, physical capital accumulation in the transition from early stage (less developed) to the later stage (developed) of development. They argue that in the early stage of development the rate of return on physical capital is higher as compared to human capital which causes, in the presence of credit market imperfection, inequality to channel resources to owners of capital with higher marginal propensity to save (MPS) that results in increased physical capital accumulation and growth. However, in the later stage the return on human capital is relatively higher, thus human capital accumulation becomes the prime engine of economic growth and equality reduces the adverse effects of credit constraints on human capital investment and increases economic growth. Hence, their theoretical work implies a nonlinear relationship between inequality and economic growth.

A few recent studies try to capture the nonlinearity between inequality and growth as implied by Galor and Moav (2004) using threshold regressions and semi-parametric techniques. For example, Lin et al (2009) use the initial level of economic development as a threshold variable to study the impact of inequality on economic growth. They conclude that inequality reduces growth in low-income countries, whereas it stimulates growth in high income countries, thus suggesting a U-shaped relationship between inequality and growth. However, their finding is not consistent with Galor and Moav (2004).

Another study by Chambers and Krause (2010) uses semiparametric methods to investigate whether the relationship between inequality and growth is affected by physical and human capital accumulation. In their growth regression, the coefficient of inequality depends on two arguments, physical and human capital, while all other effects are linear. They show that fixing educational attainment at the lower 20th

percentile level in their panel, an increase in per capita physical capital stock is associated with a steadily declining coefficient on income inequality. However, in nations with educational attainment at the median or higher level the coefficient on income inequality only decreases when per capita physical capital stock is very low, whereas it increases with larger values of the capital stock. Although their results are not fully consistent with the empirical predictions of Galor and Moav (2004), they are consistent with the terminal part of it; that is the overall effect of inequality on growth is negative.

Addressing the same issue of nonlinearity in the inequality-growth relationship as implied by Galor and Moav (2004), we investigate the changing effect of inequality on growth through two fundamental stages of development, an early stage with low human capital as compared to physical capital and a later stage with a relatively high level of human capital. To do this, we construct a new measure which is the human capital to physical capital ratio (henceforth HK ratio). By explicitly examining the ratio, we are able to be more precise in capturing the relative change in human capital as compared to physical capital in the process of economic development. Further, we study whether the inequality-growth relationship changes across the values of our new measure (HK ratio) in line with the model of Galor and Moav (2004). Our approach that directly employs the HK ratio differs from Chambers and Krause (2010), who examine this implicitly by considering the role of physical capital for fixed levels of human capital.

Methodologically, we use the relatively new technique of threshold regression with instruments as suggested by Caner and Hansen (2004). As suggested by the model of Galor and Moav (2004), the HK ratio is used as the threshold variable for the effect of inequality on growth. Since the threshold variable needs to be exogenous, lagged HK is used for this purpose. In comparison to previous studies, this is a unique work in the following senses: First, it uses a new measure of human capital to physical capital ratio (HK ratio) as the threshold variable for the effect of inequality on growth which is in line with Galor and Moav (2004). Second, it employs relatively new econometric technique of threshold regression with instrumental variables, suggested by Caner and Hansen (2004), which captures any threshold effect endogenously in the inequality-growth relationship without fixing the threshold values. Third, it employs better data on income inequality as assembled by Iradian (2005), based on information from household surveys and consistent units of measurement (as far as possible), across 82 countries for the period 1965-2003 (see the details in Section 3.4.1).

Our empirical results show that there exists a nonlinear relationship between inequality and economic growth, where at low levels of the HK ratio the effect of inequality on growth is positive and significant, while it is negative and significant at high HK levels (above the threshold). These results are consistent with the theoretical findings of Galor and Moav (2004).

This chapter is organized as follows. In section 3.2, we discuss some prominent studies from the huge literature of inequality and economic growth. Section 3.3 outlines the theoretical model of Galor and Moav (2004). Section 3.4 discusses data and econometric methodology being used in our analyses. Section 3.5 explains our empirical results and findings. Section 3.6 concludes the chapter. The full list of dataset used, details of variables and their sources, descriptive statistics, and tables of robust estimations are provided in Appendix A3, Table A3.1.

3.2. Literature Review

The current surge of theoretical and empirical literature on the inequality-growth relationship can be traced back to the seminal empirical work of Kuznets (1955). He shows that this relationship follows an 'inverse U-shape', where inequality first increases and then decreases with development. His analysis is based on time series data for England, Germany and United States, whereas he urges caution in applying this proposition to developing countries because of their data issues. Due to the shortage of time series data for developing countries, the literature during the Seventies and Eighties is mostly based on cross-sectional data and confirms the Kuznets Hypothesis despite some exceptions (see Fields, 1981).

For example, Ahluwalia (1976) is a prominent cross-sectional study which exploits the data of 20 developed and 40 developing countries. The results, based on combined data and split data on developing countries, are central to the literature on inequality and development since they confirm the Kuznets Hypothesis and have been used for projections of inequality and poverty by later studies including the World Bank (see Anand and Kanbur, 1993). On the other hand, Ram (1988) uses cross-sectional data on 24 developing and 8 developed countries; his results support the Kuznets Hypothesis if combined data is used, whereas there is very limited support in the case of developing countries. He concludes that the favourable results in a combined sample may be due to the structural differences between developed and developing countries or due to the use of dollar income variables that are based on conventional exchange rates. Further, various functional forms and larger data sets may affect the results.

Being critical of Ahluwalia's (1976) results, Anand and Kanbur (1993) test the robustness of his results to functional form and data set by employing Pesaran's (1974) econometric methodology of comparing non-nested functional forms. Their results reject Ahluwalia's (1976) log-quadratic form in favour of a straight quadratic form, where the latter exhibits a U-shape relation (opposite to Kuznets Hypothesis) between inequality and economic development. They identify the need to derive a functional form based on the theory of the underlying process. The later studies, although based on sophisticated econometric analyses and quality data of inequality also exhibit mixed evidence on Kuznets hypothesis (see Deininger and Square, 1998; Barro, 2000; Savvides and Stengos, 2000; Huang, 2004).

In this context, theoretical models try to identify channels that may explain the nature of the relationship between income inequality and growth such as credit market imperfections, majority rule (political) and technological innovation etc. For example, Galor and Zeira (1993) analyse the role of income distribution in macroeconomics through investment in human capital. They develop a two period overlapping generation model (OLG) model for open economies, where agents receive education or work in the first period and work, consume and bequest in the second period. By assuming that credit markets are imperfect and individual investments in human capital are indivisible (non-convex technology), they show that rich countries have more equal distributions of income and their all generations invest in human capital, work as skilled and leave larger bequests; whereas in poor countries people inherit less, work as unskilled and leave less for their children. Hence, initial distribution of income determines the level of aggregate investment in human capital and economic growth. Their analysis implies an 'inverse U-shape' relation between inequality and growth along the levels of income.

Besides credit market imperfections, some theoretical work calls in the political process to study the link between inequality and growth. They allow majority rule or median voter's decision to affect the distribution of income by demanding more equalizing rates of taxation which in turn affect economic growth in the future. For example, Alesina and Rodrik (1994) develop a simple endogenous growth model to argue that an unequal distribution of resources causes society members to start a political struggle for the redistribution of wealth and income resources. In their model, median voter demands a higher tax rate because the taxed income provides a public good necessary for private production, which in turn leads to equalizing wealth and income resources. Further, government's decision is the reflection of the median voter's decision, which consequently leads to lower economic growth. Hence, their model implies an inverse relationship between inequality and growth, that is, the higher the unequal distribution of income and wealth, the higher the tax rate and lower the economic growth. They confirm their theoretical findings by estimating growth regressions of income and land inequality using a cross-sectional data of 70 developed and developing countries for the period 1960-1985. A similar conclusion is drawn by Persson and Tabellini (1994) whose theoretical analysis uses tax revenues for redistributive purposes only.

The above results are criticized by Li and Zou (1998) who analyse the effect of inequality on growth using a more general framework in which the government spending is divided into production services and consumption services, where the former enters the production function while the latter enters the utility function. They show that using majority rule on income taxation, more equal income distribution can lead to higher income taxation and lower growth and in general income inequality has an ambiguous effect on economic growth. However, their empirical results show that the relationship between income inequality and economic growth is positive in all the cases and even significant in many cases which support the more general theoretical result of their model.

A relatively new wave of theoretical literature focuses on the improvement in technology and its consequences to income inequality and economic growth. This literature shows that at the initial stage of technological innovation the benefit of growth goes to high-ability individuals, hence growth increases inequality. However, at the later stage of technological innovation as the technologies become accessible the negative impact of growth on inequality diminishes. It suggests that inequality-growth relationship is positive in industrial countries who have lower barriers to access new technologies, a greater redistributive tax-transfer scheme, and a more equal distribution of income coupled with lower rates of economic growth, whereas it is negative for non-industrial countries with the opposite characteristics (see Galor and Tsiddon, 1997; Bandyopadhyay and Basu, 2005).

Recent empirical literature employs quality data on inequality, mostly as assembled by Deininger and Squire (1996), and modern econometric techniques to draw conclusions regarding the relationship between inequality and economic growth, the evidence remains mixed. On the one hand it shows a positive effect of inequality on growth which is partially consistent with the above theoretical predictions or findings. These studies criticize the previous literature on the basis of using weak proxies of inequality, data quality, and estimation methodology. They stress more careful examination of inequality-growth relationship and the channels through which it is affected (see Partridge, 1997; Li and Zou, 1998; Forbes, 2000). On the other hand it shows that the effect of inequality on growth is negative which is mainly driven by low income countries (see Panizza, 2002; Huang et al, 2009).

In this context, some empirical evidence shows that the effect of inequality on growth switches sign across the levels of income, profile of inequality, urbanization, and time etc. For example, Deininger and Squire (1998) and Barro (2000) show that the inequality decreases growth in poor countries, whereas it promotes growth in rich countries. Similarly, the profile of inequality plays an important role in understanding this relationship. Inequality at different parts of the distribution has different implications for economic growth, that is, top end inequality positively affects economic growth, whereas lower end inequality is negatively related to it (see Voitchovsky, 2005). Taking into account the urbanization factor, Fallah and Partridge (2007) use United States county data over the 1990s to show that the relationship is unstable for the entire data set, whereas its nature varies if the data is split into urban and nonurban sub samples. They observe a positive inequality-growth relationship in urban subsample, whereas inverse relationship in nonurban subsample. Similarly, Lopez (2006) observes a strong positive and robust effect of growth on inequality during 1990s, whereas no such relationship is observed during 1970s, 1980s, and in overall data. He indicates a need to identify those potential forces that might lead to this structural break during 1990s, trade liberalization and technological change may be the candidates.

Recognizing the nonlinear nature of the relationship between inequality and growth, Banerjee and Duflo (2003) criticize the results of Forbes (2000) and Li and Zou (1998) for using linear specification. They use nonparametric methods and cross-section data to show that growth rate is an inverted U-shape function of net changes in inequality (in any direction) and that this relationship is robust to control variables and estimation methods. Their empirical findings are consistent with their simple theoretical model of political economy. Similarly, Chen (2003) uses a cross-country data to show that there exists an 'inverted U-shape' relationship between initial income distribution and long run economic growth. His results are consistent with the Kuznets Hypothesis with the only difference that the long run growth first increases and then decreases with the initial inequality. He finds no support for such a relationship in the short run.

Despite of significant developments on the fronts of theory and empirical analyses in understanding inequality-growth nexus the above theoretical and empirical studies do not provide a single framework that may reconcile the two major strands of literature: First, shows the positive effect of inequality on growth via physical capital accumulation (*classical approach*). Second, argues that the effect of inequality on growth is negative using the channels of credit market imperfection, political process, and technological innovation etc. (*modern approach*).

Galor and Moav (2004) are the first to provide a unified theoretical framework by developing a two period overlapping generation model which combines these two fundamental approaches of the relationship between inequality and economic growth (*unified approach*). They argue that human capital accumulation replaces, endogenously, physical capital accumulation in the transition from early stage (less developed) to latter stage (developed) of development. They make two main conclusions: first; given a higher rate of return on physical capital as compared to human capital, in the early stage of development, inequality enhances economic growth by channelling resources towards the owners of capital with higher marginal propensity to save which leads to higher economic growth. Second, in later stage of development, the rate of return on human capital is relatively higher, thus human capital accumulation becomes the prime engine of economic growth. As human capital is inherently embodied in individuals and it exhibits diminishing marginal returns, the aggregate return to investment in human capital is maximized by equalizing the marginal returns across individuals. Therefore, in the presence of credit market imperfections, inequality leads to borrowing constraints for the poor to invest in human capital and decreases economic growth whereas equality alleviates the adverse effects of credit constrains on human capital investment and increases growth. Their theoretical contribution leads to precise channels and threshold effects that may help us understand the complexity of the relationship between inequality and economic growth.

There are only few empirical studies that look into the relationship between inequality and growth as outlined by Galor and Moav (2004). For example, Lin et al (2009) use threshold regression with instruments as suggested by Caner and Hansen (2004) to explicitly test whether there exists a threshold level of initial real per capita income above and below which inequality may affect economic growth differently. Their results show that there exists a significant threshold level and that the effect of inequality on growth is negative in poor countries, whereas it is positive in rich countries. They suggest that redistributive policy that alleviates income inequality can increase growth in developing countries, whereas rich countries need to keep a balance between worsening inequality and improving growth.

Almost similar conclusion is drawn by another important study of Chambers and Krause (2010) who examine inequality-growth relationship across fixed intervals of educational attainment coupled with steady increases in physical capital accumulation using semiparametric methods. They show that in nations with low levels of education (below median level in education series) the effect of inequality on growth is negative as we increase physical capital, whereas they observe opposite behaviour in case of higher education levels (equal to or greater than the median level). Overall, they conclude that the effect of inequality on growth is negative. The above findings are partially consistent with Galor and Moav (2004).

3.2.1. Building Testable Hypotheses

Being consistent with Galor and Moav (2004), we argue that there is need to construct a precise measure that may capture the relative change in human capital as compared to physical capital in studying the relationship between inequality and growth contrary to Chambers and Krause (2010) who fixes the education intervals and then allow physical capital to change steadily across these intervals. Hence, in this chapter we construct a new measure of human capital to physical capital ratio (HK ratio) that rises with an increase in human capital as compared to physical capital, whereas it falls for relatively lower levels of human capital as compared to physical capital. We use this measure to estimate the threshold of HK ratio below and above which inequality-growth relationship changes as predicted by Galor and Moav (2004).

Thus, following Galor and Moav (2004) and using our new measure of HK ratio we can argue that in early stage of economic development, the value of HK ratio is low because of higher return on physical capital as compared to human capital and the effect of inequality on growth is positive. However, in the later stage of economic development, human capital replaces physical capital due to relatively higher returns on it and HK ratio is high, where the effect of inequality on growth becomes negative. Therefore, on the basis of this conjecture, we establish our testable hypotheses as:

H1: *There exists a threshold level of HK ratio in the relationship between inequality and economic growth.*

H2: *The effect of inequality on economic growth is positive before a threshold value of HK ratio and it is negative after it.*

We test our hypotheses using a relatively new technique of threshold regression with instruments as developed by Caner and Hansen (2004) which endogenously captures the threshold effects in the regressions with instruments. Further, we use the GAUSS codes to implement this technique as provided by Caner and Hansen (2004) and Lin et al (2009).

3.3. An Outline of Galor and Moav (2004) Model

In this section we present a brief outline of Galor and Moav (2004) model and then discuss its testable implications.

Galor and Moav (2004) develop a theoretical model (growth theory) where human capital accumulation endogenously replaces physical capital accumulation in the transition from an early stage (less developed) to a later stage (developed) of development. They argue that in early stage of development when the credit markets are imperfect and credit constraints are binding, inequality favours physical capital accumulation and thus enhances growth, physical capital being the engine of growth. However, in later stage human capital becomes more important and equality alleviates adverse effects of credit constraint on investment in human capital and it emerges as a prime engine of growth.

Further, the fundamental hypothesis of their research emerges from the recognition that human capital accumulation and physical capital accumulation are fundamentally asymmetric. This is because human capital accumulation at individual level is subject to diminishing returns and the aggregate stock of human capital would be therefore larger if its accumulation would be widely spread among individuals in society, whereas the aggregate productivity of the stock of physical capital is largely independent of the distribution of its ownership in society.

Their theoretical model is based on three basic assumptions in addition to fundamental asymmetry between human and physical capital accumulation: First, preference structure is such that the marginal propensity to save and to bequeath increases with wealth. Second, credit market imperfection leads to inefficient investment in human capital which is consistent with the empirical evidence. Third, economy is characterized by capital-skill complementarities, where physical capital accumulation increases the demand for human capital.

In their model, production takes place within a period according to a neoclassical, constant-returns-to-scale production technology. The output produced at time 't' (Y_t) is:

$$Y_t = F(K_t, H_t) \equiv H_t f(k_t) = AH_t k_t^{\alpha}; \quad k_t = \frac{K_t}{H_t}; \quad \alpha \epsilon (0,1) \tag{3.1}$$

where K_t and H_t are the physical and human capital accumulation respectively at time 't' which are used as two factor inputs, and A is the level of technology. The production function $f(k_t)$ is monotonically increasing and strictly concave which satisfies the conditions of profit maximization problem. Assuming perfectly competitive environment, the producers' inverse demand for factors of production is given as:

$$r_t = f^{'}(k_t) = \alpha A k_t^{\alpha-1} \equiv r(k_t); \tag{3.2}$$

$$w_t = f(k_t) - f^{'}(k_t).k_t = (1-\alpha)Ak_t^{\alpha} \equiv w(k_t); \tag{3.3}$$

where, r_t is the rate of return to capital, w_t is the wage rate per efficiency unit of capital.

It is assumed that all the individuals have identical preferences and inherent abilities. However, they may vary in their parental wealth and human capital that may be due to borrowing constraints. Further, these individuals live for two periods, in first period they acquire human capital which may increase if their time investment is supplemented with capital investment in education. In second period, they supply their efficiency units of labour and allocate their wage income including their inheritance to consumption and transfers to their children. Therefore, their second period wealth is given as:

$$I_{t+1}^{i} = w_{t+1} h_{t+1}^{i} + x_{t+1}^{i} \qquad (3.4)$$

where I_{t+1}^{i} is individual's second period wealth, h_{t+1}^{i} is the acquired efficiency units of labour, w_{t+1} is the competitive wage rate at which an individual supplies his acquired efficiency units of labour, and x_{t+1}^{i} is the inherited amount of an individual. The individual allocates this wealth between consumption, c_{t+1}^{i} and transfers to the children, b_{t+1}^{i} i.e.

$$c_{t+1}^{i} + b_{t+1}^{i} \leq I_{t+1}^{i} \qquad (3.5)$$

It depicts two cases of human capital formation: First, when an individual's acquired human capital in period one is supplemented with capital investment in education. Second, when in the absence of real expenditures on education he acquires one efficiency unit of labour (basic skills). The first case is shown as under:

$$h_{t+1}^{i} = h\left(e_{t}^{i}\right) \qquad (3.6)$$

here h_{t+1}^{i} is strictly monotonically increasing and strictly concave function of real expenditures of an individual 'i' on education in time 't', e_{t}^{i}.

Now, given the properties of $f(k_t)$, there exists a unique capital-labour ratio ($\tilde{k}$) below which individuals do not invest in human capital (only basic skills), i.e.,

$$e_t = e(k_{t+1}) \begin{cases} = 0 \; if \; k_{t+1} \leq \tilde{k} \\ > 0 \; if \; k_{t+1} > \tilde{k} \end{cases} \tag{3.7}$$

here, $\acute{e}(k_{t+1}) > 0$ for $k_{t+1} > \tilde{k}$, in case when there are no credit constraints. However, if the credit constraints are binding then the expenditure on education of an individual 'i' in time 't' is limited to his inherited amount (transfers):

$$e_t^i = \min\,[e(k_{t+1}), b_t^i] \tag{3.8}$$

here b_t^i is the amount an individual 'i' receives from his parents in period 't'.

Suppose that in period '0' the economy consists of two classes or groups of adult individuals, rich (R) and poor (P). Rich are a fraction **λ** of all adults in the society who equally own the entire initial physical capital stock, whereas Poor are a fraction **(1-λ)** of all adults in the society who have no ownership over the initial stock of physical capital. All individuals and their descendents are homogeneous within their groups, whereas heterogeneous across the groups with respect to their initial capital ownership. The optimization of groups P and R of generations 't-1' and 't' in period 't' determines the aggregate level of physical capital (K_{t+1}) and human capital (H_{t+1}) in period 't+1':

$$K_{t+1} = \lambda . s_t^R + (1-\lambda) s_t^P = \lambda(b_t^R - e_t^R) + (1-\lambda)(b_t^P - e_t^P) \tag{3.9}$$

where s_t^R and s_t^P are savings by rich and poor in period 't' respectively and $K_0 > 0$, while

$$H_{t+1} = \lambda . h(e_t^R) + (1-\lambda) . h(e_t^P) \tag{3.10}$$

here in period zero there is no (non-basic) human capital, i.e. $h_0^i = 1, \;\; \forall\, i = R, P$ and thus $H_0 = 1$. Hence, given the initial values, the levels of physical and human capital in period *t+1* are functions of transfers (b_t^R, b_t^P) in each group and the capital-labour ratio in the subsequent period (k_{t+1}), i.e.,

$$H_{t+1} = H(b_t^R, b_t^P, k_{t+1}) \tag{3.11}$$

$$K_{t+1} = K(b_t^R, b_t^P, k_{t+1}) \tag{3.12}$$

Therefore, the capital-labour ratio in period *t+1* is:

$$k_{t+1} = \frac{K_{t+1}}{H_{t+1}} = \frac{K(b_t^R, b_t^P, k_{t+1})}{H(b_t^R, b_t^P, k_{t+1})}, \tag{3.13}$$

where the initial level of capital-labour ratio (k_0) is assumed to be,

$$k_0 \in (0, \tilde{k}), \tag{A1}$$

which assures that at the initial stage the return to physical capital is higher than the human capital and this assumption is consistent with the assumption of basic skills, $H_0 = 1$. Hence, from (3.11), (3.12), and (3.13), the capital-labour ratio in period 't+1' is determined by the level of transfers of groups R and P in period 't', i.e.

$$k_{t+1} = \kappa(b_t^R, b_t^P) \tag{3.14}$$

where $\kappa(0, 0) = 0$, since in absence of transfers and savings, the capital stock in the subsequent period is zero. Further, intergenerational transfers within group 'i' in period t+1, b_{t+1}^i are determined by the intergenerational transfers within the group in the preceding period and the rewards to factors of production (capital-labour ratio) in the economy, i.e.

$$b_{t+1}^i \equiv \emptyset(b_t^i, \mathrm{k}_{t+1}) \tag{3.15}$$

Let $\hat{\mathrm{k}}$ be the critical level of the capital-labour ratio below which individuals who do not receive transfers from their parents (i.e. $\mathrm{b}_\mathrm{t}^\mathrm{i} = 0$ and therefore, $\mathrm{h}(\mathrm{b}_\mathrm{t}^\mathrm{i}) = 1$) do not transfer income to their offspring, i.e. $w(\hat{k}) = \theta$, where θ is the threshold of wages or incomes. Using (3.3) and replacing k_t with $\hat{k}$, $\hat{k} = [\frac{\theta}{(1-\alpha).A}]^{\frac{1}{\alpha}} \equiv \hat{k}(\theta)$, which implies that: if $k_{t+1} \leq \hat{k}$ then $w(k_{t+1}) \leq \theta$, whereas if $k_{t+1} > \hat{k}$ then $w(k_{t+1}) > \theta$. Hence, intergenerational transfers within group 'i' in period 't+1', b_{t+1}^i are positive if and only if $k_{t+1} > \hat{k}$, i.e.

$$b_{t+1}^{i} = \emptyset(0, \mathrm{k_{t+1}}) \begin{cases} = 0 \; if \; k_{t+1} \leq \hat{k} \\ > 0 \; if \; k_{t+1} > \hat{k} \end{cases} \tag{3.16}$$

Suppose once wages increase sufficiently such that members of group P transfer resources to their offspring, that is $k_{t+1} > \hat{k}$, investment in human capital becomes profitable, that is $k_{t+1} > \tilde{k}$, hence

$$\tilde{k} \leq \hat{k} \tag{A2}$$

The evolution of transfers within each group, as follows from (3.14) and (3.15), is fully determined by the evolution of transfers within both types of dynasties,

$$b_{t+1}^{i} = \emptyset\left(b_{t}^{i}, \mathrm{k_{t+1}}\right) = \emptyset\left(b_{t}^{i}, \kappa(b_{t}^{R}, b_{t}^{P})\right) \equiv \psi^{i}(b_{t}^{R}, b_{t}^{P}); \quad i = R, P \tag{3.17}$$

Following the outcomes in period zero as discussed above, the intergenerational transfers of Rich are higher than that of members of group P (the poor) in every time period, i.e.,

$$b_{t}^{R} \geq b_{t}^{P} \text{ for all 't'} \tag{3.18}$$

Following (3.17) and (3.18), the dynamical system is uniquely determined by the joint evolution of the intergenerational transfers of Rich and Poor groups, where by imposing some additional plausible restrictions the economy endogenously evolves through two fundamental regimes:

Regime I: In this early stage of development the rate of return to human capital is lower than the rate of return to physical capital and the process of development is fuelled by capital accumulation.

Regime II: In these mature stages of development, the rate of return to human capital increases sufficiently so as to induce human capital accumulation, and the process of development is fuelled by human capital as well as physical capital accumulation.

In Regime I, the level of real expenditures on education is zero and members of both groups acquire only basic skills. The incomes or wages of Poor are below the critical level that would enable them to engage in intergenerational transfers and saving, same being true for their descendants. They are in a temporary steady-state equilibrium in which there is no investment in physical or human capital. However, Rich own the entire stock of capital in the economy and have enough income for intergenerational transfers and capital accumulation which increases over time. Their physical capital accumulation gradually raises the wage rate and the return to human capital which in turn induces the human capital accumulation and the economy enters into Regime II, where the process of development is fuelled by human capital accumulation as well as physical capital accumulation.

Regime II is subdivided into three sub-stages: Stage-I, investment in human capital is selective and it is feasible only for the Rich. The capital-labour ratio is higher than Regime-I which generates high rate of return on human capital (wages) that may justify investment in human capital but it is still below the critical level at which intergenerational transfer of resources by the Poor takes place, reasons being the absence of parental support and binding credit constraints. Stage-II, investment in human capital is universal but is still sub-optimal due to binding credit constraints. The capital-labour ratio in the economy generates wage rate that permits some investment by all members of the society. Poor’s investment in human capital remains suboptimal as compared to Rich because of their parental wealth constraint. Consequently, their marginal rate of return on investment in human capital is higher than the Rich. As human capital is inherently embodied in humans, its accumulation is larger if it is shared by a larger segment of society, thus equality in the presence of credit constraints, stimulates investment in human capital and promotes economic growth. As income further increases, credit constraints gradually diminish, differences in saving rates decline, and the effect of inequality on economic growth ultimately becomes insignificant. Stage-III, the investment in human capital is optimal since credit constraints are no longer binding and the rate of return to human capital is equalized across all the groups which cause inequality to have no effect on economic growth.

Therefore, above model implies that in the early stage of development (Regime-I) inequality between Poor and Rich is mainly due to the difference in their ownership of physical capital. As physical capital is relatively scarce in this regime, the rate of return on physical capital is higher than the human capital. Consequently, inequality favours the owners of capital (Rich) with higher marginal propensity to save (MPS) which results in increased physical capital accumulation and growth, thus economy enters in the later stage of development (Regime-II). However, in later stage of development as the wage rate of Poor gradually increases they have incentive to invest in human capital because of relatively higher rate of return on it. Thus, increased investment in human capital by the Poor induces further human capital accumulation which gradually equalizes the rate of return on human capital across all members of society in the presence of diminishing credit constraints. Hence, equality leads to higher level of human capital formation and growth, physical capital being replaced by human capital as major force behind economic growth. Therefore, in later stage inequality is harmful for growth as far as credit constraints are binding otherwise it has no effect on growth.

Following the above line of argument, we construct a new measure of human capital to physical capital ratio (HK ratio) which is low in early stage of development (Regime-I) where physical capital is the main reason of economic growth and the effect of inequality on growth is positive. However, in the later stage of development (Regime-II) human capital accumulation gradually replaces physical capital accumulation and becomes the engine of growth. Consequently, HK ratio is relatively higher in this stage and the effect of inequality on growth is negative or insignificant. Hence, our new measure of HK ratio has the ability to capture more clearly the message of Galor and Moav (2004) regarding the replacement of physical capital by human capital as the economy evolves through two fundamental regimes or stages of development.

3.4. Data and Methodology

3.4.1. Data

We use pooled data of 82 countries for the period 1965–2003. Originally, the data on real per capita GDP growth, initial real per capita GDP, inequality, secondary school enrolment, government expenditures to GDP ratio, population growth, and inflation is taken from Iradian (2005) which is further extended by including capital stock per worker, average years of schooling, trade openness and two measures of human capital to physical capital ratio; hence a total of 216 pooled observations available for our regression analysis.

While assembling his data, Iradian (2005) expanded the existing World Bank data by including comparable data on inequality from household surveys included in IMF staff reports and Poverty Reduction Strategy Papers (PRSPs). He attempts to handle the issues of data quality and measurement error by ensuring that the statistics are comparable across countries and over time using similar definitions of variables for each country and year. As most of the data on inequality uses expenditure measures, he argues that household surveys based on expenditure data are usually more accurate and yield a lower estimate of inequality as compared to income data which faces higher chance of error due to underreporting[27].

This dataset well represents all the regions (16 countries from Latin America, 12 from sub-Saharan Africa, 12 from South and East Asia, 11 from the former Soviet Union, 6 from Central and Eastern Europe, 8 from the Middle East and North Africa, and 17 OECD countries)[28]. This data is constructed following the availability of household survey data on income inequality[29] which is based on either expenditures or income per person over time. The entire sample includes 380 observations and 290 intervals. The advantage of extending the data in the temporal dimension allows us to use previous value of inequality as an instrument for the current value to control for the potential endogeneity that may exist due to feedback effect of growth on inequality.

In our threshold regressions with instruments, we use real per capita GDP growth (GROWTH) as a measure of economic growth. Log of initial value of real per capita income (LY0) is included to control for convergence, whereas population growth (POP) is included to incorporate the demographic effects. We use log of GINI coefficient (GINI) as a measure of income inequality which is estimated from the Lorenz curve and a larger value implies greater income inequality which is instrumented by its lagged value (GINI0). The scatter plots of income inequality and growth show that their relationship is non-linear; especially, it is more profound when we plot initial income inequality (GINI0) against economic growth (see

[27] For details of data issues see Iradian, G. (2005): "Inequality, poverty, and growth: Cross-country evidence," IMF Working paper, WP/05/28.
[28] List of all the data including our constructed variables is given in Appendix A3, Table A3.3.
[29] The time span between two survey years ranges from three to fourteen years. Consistent with Iradian (2005), we construct our new variables by taking their averages over the time span between two survey years.

Figures 3.1 and 3.2). As we use initial inequality (GINI0) as an instrument of GINI, we are more interested in its relationship with growth. Hence, Figure 3.2 shows that the initial and high levels of GINI0 are associated with lower growth; whereas, growth is high for medium levels of GINI0. We use log of secondary school enrolment (%) to capital stock per worker (HK) and log of average years of schooling to capital stock per worker (HKBL) as two proxies of our threshold variable (HK ratio) (see detail in Section 3.4.1.1).

For robustness of our results we include certain control variables like log of trade openness (OPEN), inflation (INF) which is included to capture the effects of macroeconomic instability, and log of government expenditures percent of GDP (GOV) that is included to incorporate the effects of fiscal policy. Moreover, we use initial values (lagged) of all other explanatory variables including threshold variables to avoid any further endogeneity. The definitions and sources of all variables used and summary statistics of the data are given in Appendix A3, Tables A3.1 and A3.2.

Figure 3.1 Income Inequality (GINI) and GROWTH

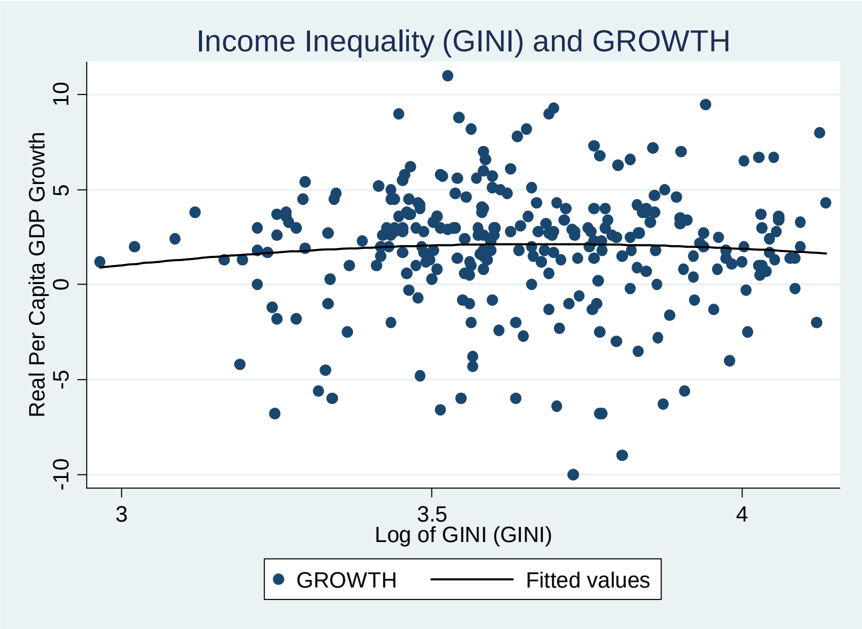
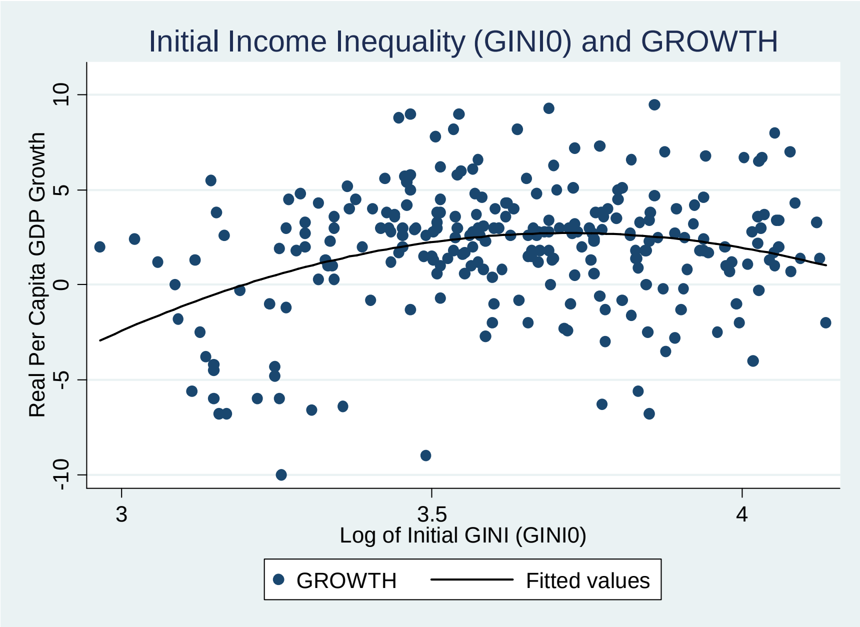


Figure 3.2 Initial Income Inequality (GINI0) and GROWTH



3.4.1.1. Human Capital to Physical Capital Ratio (HK ratio)

Consistent with Galor and Moav (2004), we construct a new measure of human capital to physical capital ratio (HK ratio) that may capture the effect of improvements in human capital relative to physical capital accumulation on the relationship between inequality and growth. This ratio increases along the relative increase in human capital and decreases along the relative decrease in human capital as compared to physical capital accumulation which is contrary to the analysis of Chambers and Krause (2010) where levels of education are fixed and the capital is allowed to increase steadily. Therefore, using HK ratio in our empirical analysis of inequality-growth relationship as predicted by Galor and Moav (2004) can help us understand whether there exists any threshold level of HK ratio below and above which the effect of inequality on growth changes.

As the level of education is low in developing countries as compared to industrialized countries (see Son, 2010), we can expect that HK ratio is relatively low for developing countries as compared to developed or industrialized countries. Hence, we can infer from Galor and Moav (2004) that at low levels of HK ratio physical capital accumulation is the main engine of economic growth and in this stage the effect of inequality on growth is positive, whereas this effect is negative after a certain threshold level of HK ratio when human capital replaces physical capital accumulation and becomes the engine of economic growth (case of industrialized countries).

Keeping in view the available proxies for human capital, we construct two HK ratios: First, based on secondary school enrolment (%) and capital stock per worker data, where HK ratio is constructed by dividing the former series by the latter (HK). Second, based on average years of schooling and capital stock per worker data, where HK ratio is constructed by taking their ratio as above (HKBL). The significance of this new measure of HK ratio can be realized after looking at our estimation results which are largely consistent with the Galor and Moav (2004). The scatter plots of our HK ratios (HK and HKBL) show that there is a weak positive relationship between these measures and economic growth (see Figures 3.3 and 3.4). However, the nonlinear relationship between HK ratios and inequality (GINI) is clear in the scatter plots of Figures 3.5 and 3.6. These plots help us to understand the threshold effects of HK ratio on inequality-growth relationship as mentioned in sub-section 3.2.1.

Figure 3.3 HK Ratio and GROWTH

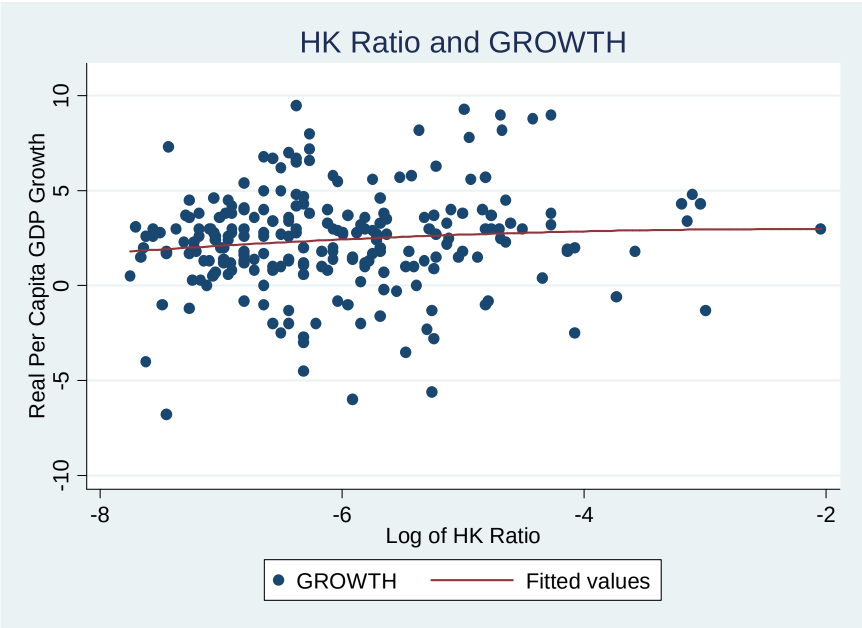


Figure 3.4 HKBL Ratio and GROWTH

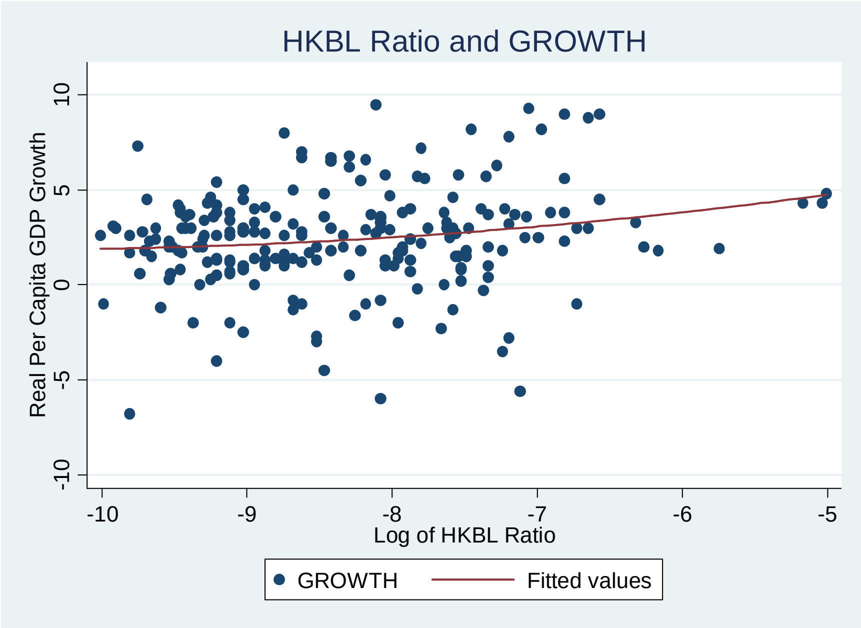


Figure 3.5 HK Ratio and Income Inequality (GINI)

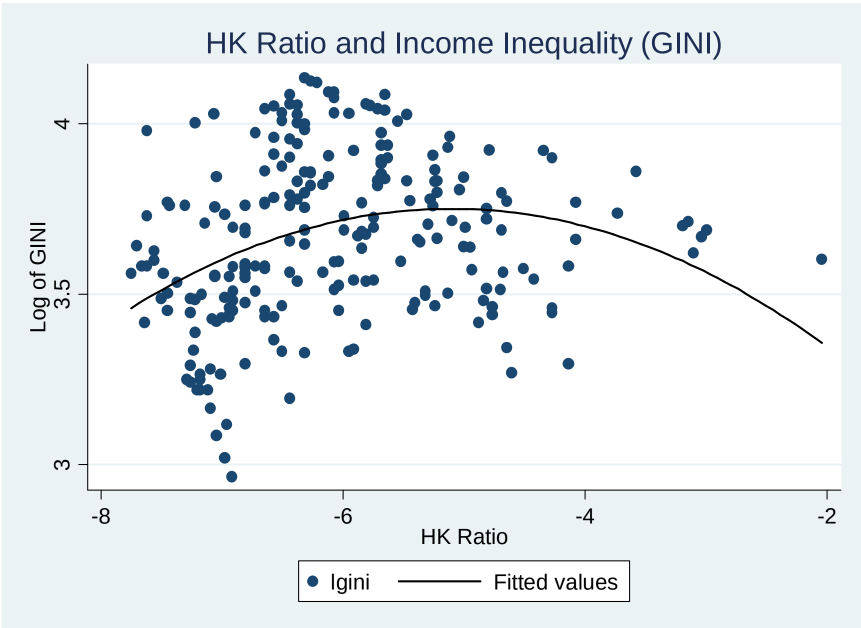
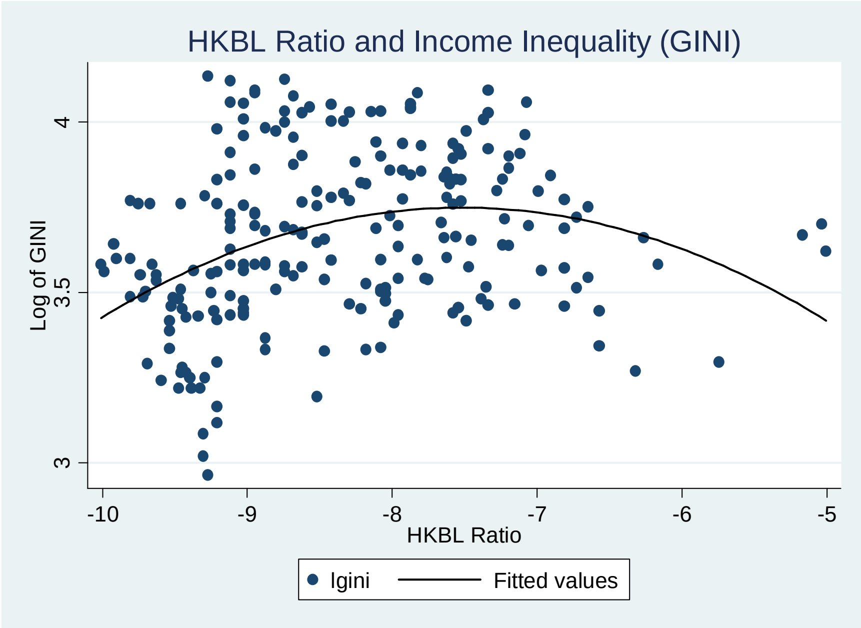


Figure 3.6 HK Ratio and Income Inequality (GINI)



3.4.2. Methodology

3.4.2.1. Threshold Regression Analysis

We use a pooled data of 82 countries for the period 1965–2003 to estimate the econometric model of the form:

$$GROWTH_{i,t} = \beta_1 + \beta_2 GINI_{i,t} + \beta_3 HK_{i,t-1} + \beta_4 LY0_{i,t-1} + \beta_5 POP_{i,t-1} + u_{i,t} \quad (3.19)$$

where GROWTH is the real per-capita GDP growth in percent, GINI is the log of GINI index that is used to measure income inequality and is instrumented by its previous value, HK is the log of human capital to physical capital ratio, LY0 is the log of initial real per capita GDP that is used to capture the issue of convergence, and POP is the population growth in percent. We also use the other control variables like trade openness (OPEN), inflation (INF), and government size (GOV) for robustness of our results. In our estimation only inequality (GINI) is treated as endogenous which is instrumented by its lagged value, whereas all other variables on right hand side of equation (1) are treated as exogenous and we use their lagged values[30].

To allow for nonlinearity in the relationship, we extend equation (3.19) into a nonlinear two-regime threshold model,

$$GROWTH_{i,t} = [\beta_{11} + \beta_{21}GINI_{i,t} + \beta_{31}HK_{i,t-1} + \beta_{41}LY0_{i,t-1} + \beta_{51}POP_{i,t-1}].\mathrm{I}.(HK_i \leq \gamma) + [\beta_{12} + \beta_{22}GINI_{i,t} + \beta_{32}HK_{i,t-1} + \beta_{42}LY0_{i,t-1} + \beta_{52}POP_{i,t-1}].\mathrm{I}.(HK_i > \gamma) + u_{i,t} \quad (3.20)$$

$$GINI_{i,t} = [\alpha_{11} + \alpha_{21}GINI_{i,t-1} + \alpha_{31}HK_{i,t-1} + \alpha_{41}LY0_{i,t-1} + \alpha_{51}POP_{i,t-1}].\mathrm{I}.(HK_i \leq \gamma) + [\alpha_{12} + \alpha_{22}GINI_{i,t-1} + \alpha_{32}HK_{i,t-1} + \alpha_{42}LY0_{i,t-1} + \alpha_{52}POP_{i,t-1}].\mathrm{I}.(HK_i > \gamma) + v_{i,t} \quad (3.21)$$

where, I(.) is the indicator function which takes the value unity when the expression in parentheses is satisfied; HK_i is the threshold variable; γ is the threshold parameter which is assumed to be same in equations (3.20) and (3.21) and $\gamma \epsilon \Gamma$, where Γ is a strict subset of the support of HK_i; and $GINI_i$ is instrumented by its previous value. This model permits the regression parameters ($\beta_{i1}, \beta_{i2}, \alpha_{i1}, \alpha_{i2}$; $\forall\, i = 1,2,\ldots,5$) to switch between regimes depending on whether HK_i is smaller or larger than the (unknown) threshold value γ.

Equation (3.20) can easily be estimated using ordinary least square (OLS) through concentration method as suggested by Hansen (2000) when all the regressors are exogenous. In this method, we estimate the threshold value γ by minimizing the concentrated sum of squared errors (SSE) function. The procedure searches for the possible values of γ that minimize the SSE function. Once the estimate of γ ($\hat{\gamma}$) is obtained, we can estimate the regression coefficients ($\hat{\beta}_{i1}, \hat{\beta}_{i2}$; $\forall\, i = 1,2,\ldots,5$) and variances. Since the threshold γ is not identified under the null hypothesis of no threshold effect, we may encounter the 'nuisance' parameter problem in the presence of which the standard asymptotic tests become nonstandard. In order to avoid this problem Hansen (1996) provides a heteroscedasticity consistent Lagrange multiplier (LM) test for the presence of a threshold and proposes a bootstrap[31] procedure to

[30] We also estimate our threshold regressions by using initial values of GINI instead of using current values with instruments. Comparing these results with our current specification, we observe minor improvements in the significance of overall threshold estimates. Further, magnitude of the coefficient on inequality changes up to some extent, whereas its sign remains unchanged.

[31] It is defined as follows: first, define the pseudodependent variable $Y_i^* = \hat{e}_i(\gamma).\eta_i$ where $\hat{e}_i(\gamma)$ is the estimated residual under the unrestricted model for each γ and η_i is independent and identically

obtain the p-values, showing that this procedure produces asymptotically correct p-values.

However, the threshold estimation methods proposed in Hansen (1996, 2000) are restricted to regression models where all right-hand side variables are exogenous. Since the inequality variable (GINI) is endogenous, possibly because of feedback from growth to inequality or because of the common effects of omitted variables on both growth and inequality, we implement the Caner and Hansen (2004) threshold regressions model with instruments to control for endogeneity.

According to Caner and Hansen (2004) the parameters in equation (3.20) can be estimated in a sequential way. First, we estimate equation (3.21) using OLS method and obtain the fitted values of our endogenous variable (GINI). Second, by substituting the fitted values of GINI ($\widehat{GINI}_i$) back in equation (3.20) we estimate threshold parameter γ using OLS through concentration method as discussed above. Third, based on threshold estimate ($\hat{\gamma}$) we split the whole sample into two subsamples and employ the generalized method of moments (GMM) method on the split subsamples to obtain the regression estimates of equation (3.20) ($\hat{\beta}_{i1}$, $\hat{\beta}_{i2}$; $\forall\ i = 1,2, \dots ,5$).

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distributed (i.i.d.) N(0,1). Second, replace original dependent variable with Y_i^* and obtain the estimated variances of residuals under restricted and unrestricted models. Finally, calculate the Wald statistic and its supremum (SupW*). The resultant supremum (SupW*) has the same asymptotic distribution as SupW which is calculated using original dependent variable. Thus by repeated simulation draws, the asymptotic p-value of the static SupW can be calculated with arbitrary accuracy (see Hansen, 1996; Caner and Hansen, 2004).

3.5. Estimation and Results

In this section we discuss our threshold regression results using different measures of HK ratio and their robustness analysis.

3.5.1. Main Results

Our estimates of threshold level and regression coefficients are given in Table 3.1. Table 3.1 uses the HK ratio (HK) as a threshold variable, where the human capital is measured as secondary school enrolment in percent[32]. Model (1) is our baseline model which shows that the threshold estimate of -5.682 is significant at 1% level. It validates the presence of threshold effect in inequality-growth relationship. Further, first column of model (1) shows the regression estimates when HK is below our estimated threshold level of -5.682, whereas second column shows the results when HK lies above the estimated threshold. First column in model (1) shows that the effect of inequality (GINI) on economic growth is positive and significant at 10% level, whereas it is negative and significant at 1% level after the estimated threshold as shown in column two. The negative and positive coefficients on HK in columns one and two respectively show that human capital is less important at the initial stage and the growth is primarily driven by physical capital accumulation, whereas it becomes important in the latter stage of development and has a positive and significant impact on economic growth. We also note that population growth has a negative and significant effect on growth irrespective of development stages.

We also check the sensitivity of our results in model (1) by including other control variables (one by one and as a group) into our baseline specification: these are trade openness (OPEN), inflation (INF) and government size (GOV). Our results from these estimations also confirm a nonlinear relationship between inequality and growth which is consistent with Galor and Moav' (2004) theoretical predictions (see Appendix A3, Table A3.4). We also note that INF and GOV have negative impact on economic growth which is consistent with our earlier findings in Chapter 2 and

[32] We take natural log of our measure of human capital to physical capital ratio (HK) to avoid the larger coefficients on it. However, taking off logs doesn't change the sign and significance of our threshold estimates, these results are given in Appendix A3, Tables A3.11 and A3.12.

empirical literature on inflation, fiscal policy, and growth (see Fisher, 1993; Easterly and Rebelo, 1993).

In order to check the robustness of our results in (1), we estimate our baseline model using data calculated over less than five year intervals and five year intervals as shown by models (2) and (3) respectively. Model (2) gives threshold regression estimates using less than five year interval data and shows that the threshold nonlinearity is significant at 10% level. Further, it shows that the effect of inequality (GINI) on economic growth is positive and significant at 5% level below the estimated threshold (-5.954), whereas it is negative and significant at 5% level above it. As we noted earlier, threshold variable (HK) is negative and insignificant below the estimated level of threshold, whereas it is positive and significant at 1% level above it. It shows that human capital is relatively unimportant in the earlier stage, whereas it is important in the later stage and it contributes positively in enhancing economic growth. Further, the signs of initial per capita GDP (LY0) and population growth (POP) are also consistent with our findings in (1).

Similarly, adding other control variables in model (2) like OPEN, INF and GOV support our main findings of (1) in Table 3.1 with respect to the sign and significance of inequality (GINI) before and after the threshold. Further, the estimated coefficient on our threshold variable (HK) also bears the same conclusions as above (see Appendix A3, Table A3.5).

Model (3) is the case of data averaged over five year intervals which shows that the threshold estimate of -5.887 is significant at 10% level. The first column of model (3) shows that the effect of inequality on growth is positive and significant at 5% level before estimated threshold, while it is negative and insignificant after it. The other explanatory variables in first column are insignificant; however, LY0 and POP are negative and significant (at 1% level) after the estimated threshold (second column).

Further, our results obtained by adding other control variables (OPEN, INF and GOV) in (3) show that if these variables are added one by one, the sign of inequality and other control variables remain consistent with our results of model (1) in Table 3.1. In case of a more general model that adds all the control variables as a group; inequality is negative before the estimated threshold, whereas it is positive after it; result being unusual among our results. However, in this case the estimated threshold as well as inequality is insignificant (see Appendix A3, Table A3.6).

Table 3.1: Baseline Threshold Model Estimates

	(1) Full data set		(2) Less than five-year averages		(3) Five-year averages	
Threshold ($\hat{\gamma}$)	-5.682		-5.954		-5.887	
LM Statistic	49.326		30.816		38.548	
p-value	0.000		0.050		0.073	
	HK <=$\hat{\gamma}$	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**
GINI	2.253* (0.071)	-5.526*** (0.008)	7.541** (0.015)	-13.215** (0.023)	2.542** (0.038)	-1.405 (0.567)
C	1.706 (0.818)	31.672*** (0.000)	-20.165 (0.189)	45.738*** (0.001)	-8.254 (0.448)	28.380*** (0.004)
HK	-0.120 (0.858)	1.080** (0.013)	-2.023 (0.1940)	2.462*** (0.000)	-0.376 (0.737)	0.124 (0.689)
LY0	-0.862** (0.020)	0.561 (0.270)	-1.853* (0.084)	2.866** (0.015)	-0.097 (0.820)	-1.557*** (0.003)
POP	-0.809** (0.026)	-3.229*** (0.000)	-2.540** (0.048)	-1.515 (0.347)	-0.030 (0.943)	-3.344*** (0.000)
Observations	147	69	32	38	72	19

Notes: The p-values are reported in the brackets. ***, **, and * indicate significant at 1%, 5%, and 10% respectively. Dependent variable is real per capita GDP growth. Threshold variable is log of human capital to physical capital ratio (HK). In constructing HK, human capital is measured as secondary school enrolment in percent, whereas physical capital is measured as capital stock per worker. Inequality (GINI) is endogenous variable which is instrumented by its lagged value. All other explanatory variables are exogenous and we use their lagged values. This table uses three pooled data sets of all cases (216), less than five year averages (70), and five year averages (91).

We also check the robustness of our baseline results in model (1) in Table 3.1 by using an alternate measure of our threshold variable. Hence, Table 3.2 uses the threshold regression estimates when HK ratio (HKBL) is calculated using average years of schooling as a proxy of human capital. Model (1) in Table 3.2 shows that there exists a threshold level of HKBL (-7.884) which is significant at 5% level. Further, model (1) confirms our previous finding of a non-linear relationship between income inequality and growth. We note that our new threshold variable (HKBL) has a positive and insignificant effect on growth below the estimated threshold, whereas it is positive and significant (at 5% level) above it. Further, the effect of population growth is negative and significant in both the columns of (1). Table A3.7 in Appendix A3 reports the results of including OPEN, INF and GOV in the above specification. It shows that in general the results are in agreement with the above findings; however, the significance of the estimated coefficients varies across the regressions.

Model (2) in Table 3.2 utilizes less-than-five-year averages data set and provides almost similar findings as of (1). Further, model (3) in Table 3.2 shows the estimated threshold regression results when the data is averaged over five years. It provides us findings which are partially in support of our baseline results of Table 3.1; where, the effect of inequality on growth is positive and significant before the estimated threshold. Moreover, the results obtained by adding our control variables (OPEN, INF and GOV) into (2) and (3) generally support our baseline findings (see Appendix A3, Tables A3.8 and A3.9).

Hence, we observe that even by changing the averaging time period of the data our main finding of (1) remains intact in the sense that the nature of the relationship between inequality and growth is nonlinear and inverted U-shaped which is in line with the theoretical outcomes of Galor and Moav (2004).

3.5.2. Further Robustness

Finally, for further robustness, we estimate our threshold regression model using the extended data of Chambers and Krause (2010) for the period 1960-2000. Their data consist of an unbalanced panel of 294 observations for 54 countries and spanning eight five-year intervals ranging from 1960-65 to 1995-2000. We extend this data by adding variables on human capital to physical capital ratio (HKBL)[33], population growth (POP), trade openness (OPEN), inflation (INF), and government expenditures (GOV)[34]. Due to some missing observations on inflation (INF) and government expenditures (GOV), we use 230 pooled observations in our analysis.

Model (4) in Table 3.2 uses Chambers and Krause' (2010) data and shows that there exists a significant threshold level of human capital to physical capital ratio (HKBL) below which the effect of inequality on economic growth is negative but insignificant. However, inequality has negative and significant impact (at 1% level) on growth after the threshold which is consistent with our baseline result of model (1), Table 3.1. Further, all the variables have insignificant coefficients when HKBL is below its threshold, whereas the coefficient of initial per capita GDP (LY0) is positive and significant (at 1%) above the threshold. We also observe that the coefficient of our threshold variable (HKBL) remains positive and insignificant in the first and second column. The results of model (4) partially support our baseline results in Table 3.1, that the effect of inequality on growth is negative and significant above the threshold of human capital to physical capital ratio. However, the differences may be due to the quality of inequality data and the composition of countries in two samples. Further, we observe almost similar findings in case we add openness (OPEN), inflation (INF) and government size (GOV) into the above specification (see Appendix A3, Table A3.10).

Overall, our threshold regression results from Tables 3.1 and 3.2 show that the relationship between inequality (as measured by log of GINI index) and economic growth is nonlinear, where inequality has positive and significant effect on growth in earlier stage of economic development when the HK ratio is below the estimated threshold level, whereas it has negative and significant impact on growth in the latter stage when the HK ratio is high and lies above the estimated threshold. Therefore, our threshold regression results verify the existence of nonlinear relationship between inequality and economic growth along the human capital to physical capital ratio (HK) as suggested by the theoretical findings of Galor and Moav (2004).

[33] Due to the limitation of secondary school enrolment data for the period 1960-2000 over five year intervals, we construct only one measure of HK ratio (HKBL) which is equal to average years of schooling (15 years or above) divided by capital stock per worker.
[34] The definitions of these variables and data sources are given in Appendix A3, Table A3.1.

Table 3.2: Baseline Threshold Model Estimates Using Alternate HK ratio Measure

	(1) Full data set		(2) Less than five-year averages		(3) Five-year averages		(4) Chambers-Krause data set	
Threshold ($\hat{\gamma}$)	-7.884		-7.967		-8.069		-8.515	
LM Statistic	30.229		32.738		37.530		36.186	
p-value	0.040		0.035		0.089		0.050	
	HKBL<=$\hat{\gamma}$	**HKBL >$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL>$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL>$\hat{\gamma}$**
GINI	2.467**	-3.427*	7.813***	-11.315**	2.461**	0.666	-0.560	-6.174***
	(0.039)	(0.073)	(0.010)	(0.038)	(0.038)	(0.816)	(0.461)	(0.000)
C	-0.078	30.546***	-15.476	48.785***	-6.739	26.975**	6.468	20.612***
	(0.992)	(0.000)	(0.342)	(0.000)	(0.618)	(0.014)	(0.313)	(0.000)
HKBL	0.063	1.184**	-1.213	2.084***	-0.100	1.245	0.257	0.952
	(0.915)	(0.011)	(0.346)	(0.000)	(0.920)	(0.354)	(0.693)	(0.1225)
LY0	-0.596**	0.138	-2.154	2.085**	-0.048	-1.218	0.009	1.533***
	(0.038)	(0.771)	(0.109)	(0.045)	(0.901)	(0.214)	(0.986)	(0.001)
POP	-0.832**	-3.307***	-2.644**	-2.174	-0.052	-3.507***	-0.227	-0.011
	(0.015)	(0.000)	(0.026)	(0.141)	(0.900)	(0.005)	(0.410)	(0.944)
Observations	142	67	30	37	71	19	156	104

Notes: The p-values are reported in the brackets. ***, **, and * indicate significant at 1%, 5%, and 10% respectively. Dependent variable is real per capita GDP growth. Threshold variable is log of human capital to physical capital ratio (HKBL). In constructing HKBL, human capital is measured as average years of schooling, whereas physical capital is measured as capital stock per worker. Inequality (GINI) is endogenous variable which is instrumented by its lagged value. All other explanatory variables are exogenous and we use their lagged values. Models (1) through (4) use our complete data set of 209 pooled observations. Model (4) uses the extended data set of Chambers and Krause (2011).

3.6. Conclusion

A huge volume of theoretical and empirical research has been devoted to understand the complex relationship between inequality and economic growth. Since the seminal work of Kuznets (1955), the empirical studies are not able to establish a clear cut view on this relationship. The reason may be the lack of theoretical base, data quality, econometric methodology, and functional specification.

However, Galor and Moav (2004) do a remarkable task of combining previous two strands of literature: classical approach and modern approach or capital market imperfection approach. They argue that in early stage of economic development, classical approach is dominant and inequality channels resources towards the owners of capital with higher marginal propensity to save, thus enhancing physical capital accumulation and growth. Moreover, human capital is less important in this stage because the marginal rate of return on physical capital is relatively higher. However, in the latter stage classical approach is dominated by the modern approach. In this stage human capital replaces physical capital and becomes a primary engine of growth because of relatively higher returns on it. Further, the wages of the poor increase and the equality alleviates the adverse effect of credit constraints on investment in human capital.

Following Galor and Moav (2004) and using our new measure of human capital to physical capital ratio (HK ratio), we establish two testable hypotheses: First, there exists a threshold of HK ratio in the relationship between inequality and growth. Second, the effect of inequality on economic growth is positive before a threshold value of HK ratio and it is negative after it. We test our hypothesis using a relatively new technique of threshold regression with instruments as suggested by Caner and Hansen (2004). Our baseline results show that there exists a significant threshold level of HK ratio below which the effect of inequality on growth is positive, whereas it is negative above it, thus validating our maintained hypotheses.

For robustness, we include certain control variables like trade openness, inflation, and government expenditures to GDP ratio which confirm the stability of our regression estimates; however the significance may vary across robust regressions. We also estimate our threshold regressions using the extended data of a closer study by Chambers and Krause (2010). Results from this data also favour the existence of a significant threshold level of human capital to physical capital ratio. However, these results are in partial agreement with our baseline results; they show that the effect of inequality on growth is negative and significant after the threshold of human capital to physical capital ratio, whereas it is negative and insignificant before threshold.

These results help us understand the complexity of the relationship between inequality and economic growth. At the initial stage of development for growth, governments may actively pursue the policy of encouraging physical capital accumulation as that is more important than human capital. However, according to our findings this emphasis on physical capital would inevitably lead to income inequality. So the policy makers and analysts should not be alarmed to see this happening as long as they want to keep their focus on generating economic growth. This gives us the next level of understanding that the governments or policy makers need to keep a close eye on when the emphasis should start changing from physical capital to human capital. Because if the economy cannot identify the need for switching this emphasis at the right time, they might eventually end up with not only high income inequality but also lower economic growth along with it.

Appendix A3

Table A3.1: Definitions and Sources of Variables used in the Analysis

Variable	Definition and construction	Source
Real per capita GDP growth (**GROWTH**)	Annual averages between two survey years and are derived from the IMF WEO and the International Financial Statistics (IFS) data bases.	Iradian's (2005) construction
Initial real per capita GDP (**LY0**)	GNP per capita at PPP from the World Bank.	Iradian (2005)
Human Capital (**HC**)	The secondary school enrolment (% of age group) is at the beginning of the period and derived from the World Bank data base.	Iradian (2005)
Human Capital (**HCBL**)	Average years of schooling, educational attainment of the total population aged 15 and over.	Barro and Lee (2010)
Per capita physical stock (**K**)	Ratio of the total stock of physical capital to labour force.	Author's construction using PWT 6.2
Human Capital to Physical Capital ratio (**HK**)	Calculated as the log of **HC** to **K** ratio	Author's construction using data from Iradian (2005) and PWT 6.2
Human Capital to Physical Capital ratio (**HKBL**)	Calculated as the log of **HCBL** to **K** ratio	Author's construction using data from Barro-Lee (2010) and PWT 6.2
Inequality (**GINI**)	The inequality data (GINI coefficient) are derived from World Bank data, OECD, and the IMF Staff Reports and Poverty Reduction Strategy Papers (PRSPs).	Iradian's (2005) construction
Initial Inequality (**GINI0**)	Initial value of **GINI**.	Iradian (2005)
Population growth rate (**POP**)	Population growth rates are from the World Bank Development Reports.	Iradian (2005)
Openness (**OPEN**)	Log of exports plus imports as percentage of GDO	Penn World Tables 6.2
Inflation (**INF**)	Inflation rates, annual averages between two survey years, are calculated using the IFS's CPI data.	Iradian (2005) construction
Government Size (**GOV**)	Data on the ratio of government expenditure as share of GDP are averages for the period between two survey years and come from the IFS.	Iradian (2005)

Table A3.2: Summary Statistics and Correlations

	GROWTH	GINI	LGINI0	LY0	HK	HKBL	POP	OPEN	INF	GOV
Mean	2.354	3.654	3.648	8.186	-6.039	-8.366	1.563	3.903	14.735	3.282
Median	2.600	3.658	3.661	8.320	-6.301	-8.503	1.600	3.938	9.000	3.256
SD	2.672	0.232	0.243	1.040	1.070	0.990	0.991	0.549	18.795	0.412
Min	-6.750	2.965	2.965	5.561	-7.752	-10.000	-0.500	2.220	-1.000	2.477
Max	9.500	4.094	4.079	10.062	-2.064	-5.009	4.200	5.321	150.000	4.168
Correlations										
GROWTH	1.000									
GINI	-0.022	1.000								
GINI0	-0.047	0.920	1.000							
LY0	-0.141	-0.232	-0.202	1.000						
HK	0.116	0.194	0.133	-0.826	1.000					
HKBL	0.139	0.251	0.192	-0.755	0.890	1.000				
POP	-0.118	0.532	0.513	-0.661	0.604	0.589	1.000			
OPEN	-0.103	0.035	0.051	0.205	-0.197	-0.043	-0.041	1.000		
INF	-0.257	0.209	0.169	-0.154	0.061	0.088	0.126	-0.134	1.000	
GOV	-0.206	-0.540	-0.512	0.622	-0.631	-0.662	-0.641	0.262	-0.118	1.000

Note: GINI is the log of GINI coefficient, GINI0 is the log of initial value of GINI coefficient, LY0 is the log of initial per capita GDP, HK is the log of human capital (Secondary school enrolment, %) to physical capital ratio, HKBL is the log of human capital (average years of schooling) to physical capital ratio, POP is the population growth rate, OPEN is the log of exports plus imports percent of GDP, INF is the inflation rate, and GOV is log of govt. expenditures percent of GDP.

Table A3.3: Dataset

Originally the data is taken from Iradian (2005). We extend it by adding two measures of human capital to physical capital ratio (HK and HKBL) and trade openness (OPEN). These variables are constructed by taking their average over the time span between two surveys. Following is the list of selected data used in our analysis. GROWTH is real per capita GDP growth. LY0 is initial per capita GDP. GINI is inequality defined as the value of GINI coefficient. GINI0 is initial GINI. HK is secondary school enrolment (%) to capital stock per worker ratio. HKBL is average years of schooling to capital stock per worker ratio. OPEN is the exports plus imports percent of GDP. In our threshold analysis "less than five years averages" and "five years averages" means the cases for which the data is averaged over a time span of less than five and five years respectively. Our full sample includes all of the following cases for which data is available. This information is shown in the 3rd column in the following table.

Country	House Hold Survey Year	Averaging Time Span	GROWTH	LY0	GINI	GINI0	HK	HKBL	OPEN
Algeria	1995	7.0	-2.0	4060.0	35.3	38.7	1.6E-03	8.5E-05	37.2
Algeria	1998	3.0	1.0	4358.0	35.3	35.3	2.1E-03	1.2E-04	49.6
Argentina	1996	6.0	5.0	9489.0	48.2	44.7	1.5E-03	1.7E-04	15.0
Argentina	1998	2.0	7.0	11172.0	49.5	48.2	1.6E-03	1.8E-04	17.4
Argentina	2001	3.0	-1.3	12162.0	52.2	49.5	1.6E-03	1.7E-04	23.6
Armenia	1998	9.0	-6.0	2580.0	37.9	25.9	.	.	.
Armenia	2001	3.0	7.0	1850.0	36.0	59.0	.	.	81.2
Armenia	2003	2.0	11.0	.	34.0	.	.	.	71.6
Australia	1985	5.0	2.8	10016.0	37.6	39.3	5.2E-04	1.1E-04	31.7
Australia	1990	5.0	2.6	12790.0	41.7	37.6	4.9E-04	1.1E-04	31.0
Australia	1994	4.0	0.5	17314.0	35.2	41.7	4.3E-04	1.0E-04	32.6
Austria	1976	6.0	4.5	6200.0	31.2	29.3	9.7E-04	1.2E-04	58.1
Austria	1981	5.0	3.6	6722.0	31.4	31.2	7.0E-04	9.8E-05	59.8
Austria	1987	6.0	1.7	10829.0	31.6	31.4	5.8E-04	7.9E-05	67.6
Austria	1995	8.0	2.0	15648.0	30.5	31.6	4.8E-04	7.2E-05	68.5
Azerbaijan	1995	6.0	-9.0	2310.0	45.0	32.8	.	.	.
Azerbaijan	2002	7.0	5.1	1790.0	36.5	45.0	.	.	114.5
Bangladesh	1982	8.0	1.9	260.0	27.0	25.9	1.6E-02	3.2E-03	8.9
Bangladesh	1986	4.0	3.3	420.0	26.3	27.0	1.0E-02	1.8E-03	18.7
Bangladesh	1992	6.0	4.5	570.0	28.3	26.3	9.6E-03	1.4E-03	18.8
Bangladesh	1996	4.0	3.0	845.0	33.6	28.3	9.1E-03	1.2E-03	20.2
Bangladesh	2000	4.0	3.8	1006.0	31.8	33.6	1.4E-02	1.1E-03	28.0
Belarus	1995	6.0	-2.5	6728.0	28.9	22.8	.	.	.
Belarus	2000	5.0	5.2	4939.0	30.4	28.9	.	.	103.7
Belgium	1985	5.0	3.6	10517.0	26.2	28.3	9.0E-04	8.1E-05	117.0
Belgium	1990	5.0	3.0	12908.0	26.6	26.2	8.3E-04	7.9E-05	136.2
Belgium	1996	6.0	1.8	18347.0	25.0	26.6	7.4E-04	7.7E-05	132.4
Brazil	1975	5.0	8.0	.	61.9	57.6	1.9E-03	1.6E-04	7.1
Brazil	1985	10.0	1.4	.	59.5	61.9	1.6E-03	1.3E-04	8.7
Brazil	1988	3.0	4.3	.	62.5	59.5	1.8E-03	9.4E-05	16.3

Brazil	1993	5.0	-2.0	.	61.6	62.5	2.0E-03	1.1E-04	15.9
Brazil	1996	3.0	3.3	.	60.0	61.6	2.2E-03	1.3E-04	16.6
Brazil	2001	5.0	1.4	.	59.0	60.0	2.3E-03	1.7E-04	17.3
Bulgaria	1994	5.0	-4.2	6126.0	24.3	23.3	.	.	.
Bulgaria	2001	7.0	-0.3	5485.0	31.9	24.3	.	.	89.4
Cameroon	1996	12.0	-2.8	2215.0	47.7	49.0	5.3E-03	7.5E-04	43.0
Cameroon	2001	5.0	2.5	1843.0	44.6	47.7	9.2E-03	9.2E-04	38.2
Canada	1970	5.0	3.0	4388.3	32.3	31.6	1.1E-03	1.2E-04	37.3
Canada	1975	5.0	3.0	5600.7	31.6	32.3	1.0E-03	1.2E-04	40.9
Canada	1980	5.0	2.6	7148.0	31.0	31.6	9.7E-04	1.1E-04	45.3
Canada	1985	5.0	1.2	11434.0	32.8	31.0	9.3E-04	1.1E-04	50.3
Canada	1990	5.0	2.6	14529.0	30.6	32.8	8.7E-04	1.0E-04	51.6
Canada	1998	8.0	0.3	19407.0	33.1	27.6	7.7E-04	9.6E-05	53.0
Chile	1980	5.0	1.4	1439.0	53.2	46.0	1.2E-03	1.5E-04	52.6
Chile	1987	7.0	1.0	2643.0	56.4	53.2	1.5E-03	1.6E-04	46.2
Chile	1990	3.0	6.7	3999.0	56.1	56.4	1.7E-03	1.8E-04	47.9
Chile	1994	4.0	6.5	4810.0	54.8	56.1	1.7E-03	2.2E-04	61.8
Chile	1997	3.0	6.7	6743.0	57.5	54.8	1.4E-03	2.2E-04	56.1
Chile	2000	3.0	1.7	8442.0	57.1	57.5	1.3E-03	1.9E-04	56.2
China	1985	4.0	9.0	483.0	31.4	32.0	1.4E-02	1.4E-03	15.7
China	1990	5.0	8.8	797.0	34.6	31.4	1.2E-02	1.3E-03	18.5
China	1994	4.0	9.0	1332.0	40.0	34.6	9.2E-03	1.1E-03	28.1
China	1998	4.0	9.3	2230.0	40.3	40.0	6.8E-03	8.6E-04	35.9
China	2001	3.0	6.3	3197.0	44.7	40.3	5.4E-03	6.9E-04	38.3
Colombia	1991	3.0	2.0	4538.0	51.3	53.1	3.4E-03	3.6E-04	29.9
Colombia	1996	5.0	2.4	4818.0	57.1	51.3	3.3E-03	3.8E-04	33.5
Colombia	1999	3.0	1.3	6074.0	57.6	57.1	3.1E-03	3.8E-04	35.5
Costa Rica	1990	4.0	2.5	4130.0	45.6	34.4	3.3E-03	5.0E-04	56.2
Costa Rica	1993	3.0	2.7	5070.0	46.3	45.6	3.3E-03	5.0E-04	65.0
Costa Rica	1996	3.0	3.3	6100.0	47.1	46.3	3.4E-03	4.9E-04	74.6
Costa Rica	2000	4.0	3.8	6670.0	46.5	47.1	3.5E-03	4.8E-04	78.9
Czech Republic	1993	4.0	-1.8	.	26.6	.	.	.	.
Czech Republic	1996	3.0	1.7	.	25.4	.	.	.	95.1
Dominican Rep.	1985	5.0	0.2	.	43.3	.	2.9E-03	5.4E-04	81.0
Dominican Rep.	1989	4.0	1.5	.	50.5	.	2.7E-03	5.3E-04	83.2
Dominican Rep.	1997	8.0	0.8	.	49.7	.	2.2E-03	5.4E-04	110.0
Ecuador	1995	3.0	2.0	.	54.8	.	7.3E-04	2.4E-04	59.2
Ecuador	1998	3.0	0.5	.	56.2	.	8.5E-04	2.5E-04	52.3
Egypt	1990	8.0	2.9	1533.0	34.0	32.2	2.4E-03	2.8E-04	65.6
Egypt	1995	5.0	1.4	2416.0	34.5	34.0	2.7E-03	3.5E-04	52.6
Egypt	2000	5.0	3.0	2844.0	34.4	34.5	3.0E-03	4.3E-04	56.4
El Salvador	1995	6.0	2.7	2897.0	51.3	49.0	3.6E-03	5.1E-04	36.9
El Salvador	2000	5.0	1.8	4081.0	53.2	51.3	3.4E-03	5.6E-04	52.3

Estonia	1995	6.0	-3.8	8678.0	35.4	23.0	.	.	.
Estonia	2000	5.0	6.1	6922.0	37.6	35.4	.	.	115.4
Ethiopia	1995	14.0	-1.3	412.0	40.0	32.0	5.0E-02	.	31.3
Ethiopia	2000	5.0	3.4	465.0	41.0	40.0	4.3E-02	.	26.5
Finland	1975	5.0	5.4	4773.8	27.0	31.8	1.1E-03	1.0E-04	50.7
Finland	1980	5.0	2.0	5808.0	30.9	27.0	9.1E-04	8.8E-05	51.3
Finland	1985	5.0	3.0	9240.0	30.8	30.9	8.4E-04	8.1E-05	55.9
Finland	1990	5.0	3.8	12207.0	26.2	30.8	7.6E-04	7.8E-05	58.6
Finland	1995	5.0	-1.2	17610.0	25.6	26.2	7.0E-04	6.8E-05	49.3
Finland	2000	5.0	4.5	.	26.9	.	7.0E-04	6.2E-05	56.8
France	1970	5.0	3.4	4170.6	44.0	47.0	1.4E-03	9.2E-05	25.8
France	1975	5.0	4.0	5322.8	43.0	44.0	1.1E-03	7.8E-05	27.8
France	1980	5.0	2.4	6476.0	34.9	43.0	9.7E-04	6.6E-05	35.4
France	1985	5.0	0.6	10281.0	34.9	34.9	8.6E-04	5.9E-05	41.0
France	1995	10.0	1.7	12890.0	32.7	34.9	7.0E-04	5.5E-05	46.7
Georgia	1995	6.0	-10.0	4844.0	41.6	26.0	.	.	.
Georgia	2002	7.0	5.1	1422.0	38.9	41.6	.	.	78.3
Germany	1975	5.0	2.6	5268.6	36.6	39.2	5.2E-04	5.5E-05	33.0
Germany	1980	5.0	3.0	6410.0	36.6	36.6	5.2E-04	5.0E-05	34.7
Germany	1985	5.0	-1.0	10549.0	35.2	36.6	5.6E-04	4.6E-05	40.7
Germany	1990	5.0	2.6	13330.0	36.0	35.2	4.9E-04	4.5E-05	48.1
Germany	1998	8.0	3.1	18531.0	38.2	36.0	4.5E-04	4.9E-05	46.3
Ghana	1992	5.0	2.0	1236.0	38.9	35.4	1.7E-02	1.9E-03	44.6
Ghana	1998	6.0	1.8	1456.0	36.0	38.9	1.6E-02	2.1E-03	42.4
Honduras	1995	5.0	1.0	2216.0	56.1	57.6	4.2E-03	6.5E-04	77.1
Honduras	1999	4.0	-0.3	2417.0	55.0	56.1	3.9E-03	6.3E-04	80.1
Hungary	1993	4.0	-4.5	9566.0	27.9	23.3	1.8E-03	2.1E-04	83.9
Hungary	1998	5.0	1.3	8471.0	24.4	27.9	1.6E-03	2.0E-04	77.8
India	1984	6.0	1.5	561.0	30.5	33.1	7.6E-03	5.6E-04	12.1
India	1988	4.0	3.0	848.0	31.2	30.5	8.5E-03	5.1E-04	13.9
India	1994	6.0	3.7	1298.0	31.9	31.2	8.5E-03	6.5E-04	12.3
India	1997	3.0	5.7	1709.0	33.7	31.9	8.1E-03	6.4E-04	17.8
India	2000	3.0	4.0	2010.0	32.5	37.8	7.9E-03	6.2E-04	23.3
Indonesia	1980	10.0	5.6	400.0	35.6	30.7	7.2E-03	1.1E-03	29.6
Indonesia	1987	7.0	3.7	836.0	32.0	35.6	5.3E-03	7.8E-04	43.9
Indonesia	1993	6.0	5.8	1489.0	31.7	32.0	4.4E-03	5.3E-04	46.9
Indonesia	1996	3.0	5.7	2400.0	36.5	31.7	4.0E-03	4.0E-04	48.8
Indonesia	1999	3.0	-2.0	3029.0	31.0	36.5	1.4E-03	3.5E-04	52.7
Iran	1990	4.0	-6.8	3523.0	43.4	47.0	5.8E-04	5.5E-05	12.9
Iran	1994	4.0	7.3	3219.0	43.0	43.4	5.9E-04	5.8E-05	27.8
Iran	1998	4.0	2.3	3665.0	43.0	43.0	6.7E-04	6.3E-05	46.0
Ireland	1975	5.0	3.6	3376.0	38.7	43.7	1.6E-03	2.1E-04	74.9
Ireland	1980	5.0	2.6	3376.0	35.7	38.7	1.3E-03	1.8E-04	78.3
Ireland	1985	5.0	1.2	5740.0	35.2	35.7	1.1E-03	1.6E-04	100.2

Ireland	1996	11.0	4.1	.	35.9	.	1.1E-03	1.4E-04	103.0
Italy	1980	5.0	3.0	5806.0	34.3	39.0	6.3E-04	6.6E-05	40.6
Italy	1985	5.0	1.8	9813.0	33.2	34.3	5.8E-04	6.1E-05	45.7
Italy	1990	5.0	2.8	12547.0	32.7	33.2	5.5E-04	6.0E-05	45.6
Italy	1998	8.0	1.5	17990.0	36.0	32.7	4.7E-04	6.4E-05	38.5
Ivory Coast	1989	4.0	-2.4	1479.0	36.9	41.2	.	.	.
Ivory Coast	1995	6.0	3.0	1500.0	36.7	36.9	.	.	.
Ivory Coast	1998	3.0	4.0	1600.0	43.8	36.7	.	.	.
Jamaica	1996	6.0	1.7	3638.0	40.3	51.7	3.2E-03	3.5E-04	107.5
Jamaica	1999	3.0	-2.0	3526.0	37.9	54.4	2.9E-03	3.5E-04	114.4
Japan	1975	5.0	4.8	4255.6	34.4	35.5	1.7E-03	2.1E-04	20.3
Japan	1980	5.0	3.6	5695.0	33.4	34.4	1.2E-03	1.5E-04	22.5
Japan	1985	5.0	3.8	9459.0	35.9	33.4	1.0E-03	1.1E-04	24.6
Japan	1990	5.0	4.6	12532.0	35.0	35.9	8.6E-04	9.6E-05	27.0
Jordan	1992	6.0	-2.7	3440.0	38.4	36.1	1.8E-03	2.0E-04	84.7
Jordan	1997	5.0	1.8	3560.0	36.4	40.0	2.3E-03	2.2E-04	128.2
Jordan	2003	6.0	-0.8	3765.0	36.5	38.1	2.4E-03	3.1E-04	125.5
Kazakhstan	1996	7.0	-4.3	4701.0	35.4	25.7	.	.	.
Kazakhstan	2001	5.0	2.8	3452.0	31.2	35.4	.	.	80.3
Korea Rep.	1970	5.0	8.2	710.0	35.3	34.3	9.3E-03	9.4E-04	24.2
Korea Rep.	1975	5.0	7.8	1032.4	38.0	33.3	7.1E-03	7.5E-04	35.4
Korea Rep.	1980	5.0	8.2	1435.0	38.6	38.0	4.7E-03	5.8E-04	54.2
Korea Rep.	1985	5.0	5.6	2573.0	34.5	38.6	3.2E-03	4.2E-04	63.8
Korea Rep.	1990	5.0	5.8	4155.0	33.6	34.5	2.3E-03	3.2E-04	68.9
Korea Rep.	1995	5.0	6.2	7522.0	32.0	33.6	1.5E-03	2.5E-04	64.4
Kyrgyz Rep.	1996	7.0	-6.4	2010.0	40.5	28.7	.	.	.
Kyrgyz Rep.	1999	3.0	5.0	1217.0	37.0	40.5	.	.	76.9
Kyrgyz Rep.	2003	4.0	4.5	1349.0	31.0	44.7	.	.	92.7
Latvia	1994	5.0	-5.6	8740.0	27.6	22.5	.	.	.
Latvia	1998	4.0	4.3	5040.0	32.4	27.6	.	.	110.5
Lesotho	1993	5.0	3.6	756.0	57.9	56.0	3.0E-03	8.5E-04	149.6
Lesotho	1995	2.0	2.0	1341.0	60.0	57.9	2.3E-03	6.5E-04	141.7
Lithuania	1993	4.0	-6.6	9130.0	33.6	27.3	.	.	.
Lithuania	1996	3.0	-0.7	6156.0	32.4	33.6	.	.	172.9
Lithuania	2000	4.0	4.5	6800.0	31.9	33.6	.	.	113.9
Madagascar	1993	14.0	-2.5	650.0	43.4	46.9	1.7E-02	.	49.3
Madagascar	1997	4.0	-0.6	759.0	42.0	43.4	2.4E-02	.	37.7
Madagascar	2001	4.0	1.8	775.0	47.5	46.0	2.8E-02	.	51.3
Malaysia	1980	10.0	4.6	1371.0	49.1	51.3	3.4E-03	5.1E-04	77.3
Malaysia	1985	5.0	4.0	2318.0	46.8	49.1	2.2E-03	3.8E-04	91.1
Malaysia	1990	5.0	1.8	3167.0	45.7	46.8	2.1E-03	2.7E-04	108.1
Malaysia	1995	5.0	6.6	4562.0	45.6	45.7	1.9E-03	2.8E-04	125.6
Malaysia	2000	5.0	2.6	7235.0	44.3	45.6	1.6E-03	2.4E-04	168.0
Mali	1994	5.0	0.4	550.0	50.5	36.5	1.3E-02	6.5E-04	48.0

Mali	2001	7.0	3.2	609.0	49.4	50.5	1.4E-02	7.5E-04	53.5
Mauritania	1996	6.0	0.0	1217.0	38.9	40.1	4.6E-03	4.8E-04	101.3
Mauritania	2000	4.0	1.5	1612.0	39.0	38.9	5.4E-03	5.2E-04	99.6
Mexico	1970	5.0	2.8	1410.5	57.7	55.5	1.7E-03	1.2E-04	18.7
Mexico	1975	5.0	3.4	1887.6	57.9	57.7	1.6E-03	1.1E-04	18.1
Mexico	1980	5.0	3.4	2526.0	50.0	57.9	1.4E-03	1.1E-04	18.9
Mexico	1984	4.0	0.8	4395.0	52.5	50.0	1.4E-03	1.2E-04	24.0
Mexico	1988	4.0	-2.5	4954.0	55.1	52.5	1.5E-03	1.2E-04	30.9
Mexico	1995	7.0	1.1	5966.0	53.7	55.1	1.8E-03	1.4E-04	36.2
Mexico	2000	5.0	1.2	7042.0	54.6	53.7	1.8E-03	1.6E-04	39.8
Morocco	1990	5.0	2.8	2040.0	39.3	39.2	2.8E-03	1.8E-04	57.9
Morocco	1999	9.0	1.2	2781.0	39.5	39.3	3.0E-03	1.8E-04	50.2
Nepal	1989	4.0	3.0	619.0	35.7	33.4	1.1E-02	5.7E-04	31.5
Nepal	1996	7.0	3.0	826.0	36.7	35.7	1.3E-01	4.9E-04	32.3
Netherlands	1985	4.0	0.3	10428.0	28.1	28.3	7.2E-04	7.2E-05	114.4
Netherlands	1989	4.0	2.3	12632.0	29.6	28.1	7.3E-04	7.2E-05	117.1
Netherlands	1994	5.0	2.0	17147.0	32.6	29.6	7.3E-04	7.4E-05	105.6
New Zealand	1980	5.0	-0.8	6251.0	34.8	30.0	1.1E-03	1.7E-04	52.6
New Zealand	1985	5.0	1.6	8490.0	35.8	34.8	1.1E-03	1.6E-04	56.9
New Zealand	1990	5.0	2.6	11447.0	40.2	35.8	1.1E-03	1.6E-04	61.7
New Zealand	1996	6.0	1.3	13586.0	36.2	40.2	1.1E-03	1.4E-04	51.7
Nigeria	1993	8.0	1.5	493.0	45.0	38.7	6.5E-03	.	25.4
Nigeria	1997	4.0	-0.8	812.0	50.6	45.0	8.3E-03	.	50.3
Norway	1986	4.0	3.8	12703.0	22.6	23.4	9.5E-04	1.0E-04	77.9
Norway	1990	4.0	1.3	18509.0	23.7	22.6	8.3E-04	1.0E-04	76.0
Norway	1995	5.0	2.6	22429.0	25.8	23.7	7.6E-04	9.2E-05	70.4
Norway	2000	5.0	3.7	.	25.8	.	6.8E-04	8.3E-05	70.1
Pakistan	1980	10.0	1.0	340.0	32.3	33.6	4.5E-03	3.2E-04	13.7
Pakistan	1985	5.0	3.6	669.0	33.4	37.3	4.9E-03	3.1E-04	22.1
Pakistan	1993	8.0	3.3	952.0	33.2	33.4	5.9E-03	3.1E-04	24.5
Pakistan	1999	6.0	1.3	1380.0	33.0	33.2	4.9E-03	3.2E-04	26.6
Panama	1996	7.0	3.7	3497.0	56.3	56.6	2.6E-03	2.9E-04	129.6
Panama	2000	4.0	3.0	5077.0	56.4	56.3	2.3E-03	3.1E-04	168.0
Paraguay	1995	5.0	-0.2	4050.0	59.5	49.7	3.5E-03	4.0E-04	72.7
Paraguay	1999	4.0	0.7	4605.0	56.8	59.1	3.5E-03	3.8E-04	78.6
Peru	1994	9.0	-1.6	3267.0	48.6	45.7	3.4E-03	2.6E-04	43.8
Peru	2000	6.0	3.5	3943.0	49.4	44.6	3.6E-03	3.1E-04	29.2
Philippines	1988	3.0	-2.3	2373.0	40.7	41.0	5.0E-03	4.7E-04	47.0
Philippines	1991	3.0	3.0	3110.0	43.8	40.7	5.1E-03	4.9E-04	53.0
Philippines	1994	3.0	-1.3	3167.0	42.9	43.8	5.2E-03	5.1E-04	60.6
Philippines	1997	3.0	2.7	3332.0	46.2	42.9	5.4E-03	5.2E-04	68.0
Philippines	2000	3.0	0.9	3712.0	46.1	46.2	5.3E-03	5.4E-04	92.6
Poland	1993	4.0	-1.0	5740.0	28.0	25.5	2.6E-03	2.8E-04	33.8
Poland	1999	6.0	5.5	6187.0	31.6	23.2	2.4E-03	2.7E-04	44.1

Portugal	1990	5.0	5.0	6948.0	31.0	32.0	1.3E-03	1.2E-04	68.6
Portugal	1998	8.0	2.8	10878.0	31.6	31.0	1.3E-03	1.2E-04	68.3
Romania	1994	5.0	-6.0	5730.0	28.2	23.3	2.7E-03	3.1E-04	39.0
Romania	2000	6.0	1.0	5144.0	30.3	28.2	3.0E-03	3.4E-04	49.8
Russia	1994	5.0	-6.8	8817.0	43.6	23.8	.	.	.
Russia	1996	2.0	-6.3	7038.0	48.1	43.6	.	.	59.9
Russia	2000	4.0	-0.2	6045.0	45.6	48.1	.	.	51.7
Senegal	1995	4.0	-1.0	1157.0	41.3	54.1	8.1E-03	1.2E-03	54.6
Senegal	2001	6.0	3.0	1188.0	42.6	41.3	8.1E-03	1.3E-03	59.9
Slovenia	1994	5.0	-1.8	11340.0	25.8	22.0	.	.	.
Slovenia	1998	4.0	4.8	11700.0	28.4	26.8	.	.	136.1
Spain	1980	5.0	0.8	4802.0	33.4	37.1	1.0E-03	7.8E-05	29.0
Spain	1985	5.0	0.6	7074.0	31.8	33.4	9.7E-04	7.3E-05	29.3
Spain	1990	5.0	4.2	8637.0	32.5	31.8	1.0E-03	7.7E-05	38.8
Sri Lanka	1979	14.0	2.3	510.0	43.5	47.0	9.6E-03	1.1E-03	74.8
Sri Lanka	1987	8.0	3.8	848.0	46.7	43.5	6.7E-03	1.0E-03	60.3
Sri Lanka	1991	4.0	1.8	1679.0	38.1	46.7	6.7E-03	7.2E-04	70.8
Sri Lanka	1996	5.0	4.0	1956.0	41.1	30.1	6.1E-03	7.3E-04	66.4
Sweden	1980	5.0	1.2	6748.0	19.4	21.3	9.9E-04	9.4E-05	55.5
Sweden	1985	5.0	2.0	9975.0	20.5	19.4	9.3E-04	9.1E-05	57.5
Sweden	1990	5.0	2.4	12999.0	21.9	20.5	8.7E-04	9.1E-05	66.6
Sweden	1995	5.0	0.0	17719.0	25.0	21.9	8.1E-04	8.9E-05	62.1
Sweden	2000	5.0	3.0	.	25.0	.	7.6E-04	8.4E-05	61.4
Tajikistan	1999	10.0	-6.0	1954.0	34.7	25.0	.	.	.
Tajikistan	2003	4.0	6.0	707.0	36.0	34.7	.	.	161.6
Thailand	1981	6.0	7.2	776.0	47.3	41.7	1.9E-03	4.1E-04	39.6
Thailand	1985	4.0	3.8	1572.0	47.4	43.1	1.9E-03	3.6E-04	48.1
Thailand	1988	3.0	4.7	1999.0	47.4	47.4	1.8E-03	3.3E-04	47.4
Thailand	1992	4.0	9.5	3104.0	51.5	47.4	1.7E-03	3.0E-04	58.1
Thailand	1996	4.0	6.8	4530.0	43.4	51.5	1.3E-03	2.5E-04	76.4
Thailand	2000	4.0	-1.0	5652.0	43.2	41.4	1.3E-03	1.8E-04	85.0
Tunisia	1980	5.0	4.2	3450.0	46.1	50.6	1.7E-03	1.0E-04	66.9
Tunisia	1985	5.0	1.4	2338.0	43.0	46.1	1.6E-03	1.0E-04	75.4
Tunisia	1990	5.0	0.6	2978.0	40.0	43.0	1.8E-03	1.1E-04	80.9
Tunisia	1995	5.0	2.8	3755.0	41.7	40.0	2.5E-03	1.3E-04	81.9
Tunisia	2000	5.0	3.2	4780.0	39.8	41.7	2.9E-03	1.7E-04	89.3
Turkey	1975	5.0	2.2	1436.5	51.0	56.0	5.9E-03	4.1E-04	10.0
Turkey	1987	12.0	1.8	1586.0	43.6	51.0	4.3E-03	3.6E-04	14.9
Turkey	1994	7.0	2.9	3933.0	41.5	43.6	3.2E-03	3.3E-04	23.0
Turkey	2000	6.0	2.7	4857.0	40.0	41.5	2.5E-03	3.0E-04	33.3
Uganda	1992	3.0	4.3	710.0	39.2	37.3	4.8E-02	5.7E-03	24.5
Uganda	1996	4.0	4.8	800.0	37.4	39.2	4.5E-02	6.7E-03	27.1
Uganda	2000	4.0	4.3	1070.0	40.5	37.4	4.1E-02	6.5E-03	32.7
Ukraine	1989	3.0	-6.8	7210.0	25.7	23.5	.	.	.

Ukraine	1998	6.0	-4.8	6315.0	32.5	25.7	.	.	.
United Kingdom	1980	3.0	2.7	5901.0	28.0	27.0	1.5E-03	1.4E-04	58.3
United Kingdom	1985	5.0	1.0	9175.0	29.0	28.0	1.4E-03	1.4E-04	54.0
United Kingdom	1990	5.0	4.0	11711.0	36.0	29.0	1.3E-03	1.3E-04	53.2
United Kingdom	1995	5.0	0.8	16857.0	36.0	36.0	1.2E-03	1.2E-04	51.1
Uruguay	1995	6.0	2.0	12521.0	42.7	42.2	1.8E-03	2.0E-04	44.6
Uruguay	1999	4.0	3.0	12457.0	43.8	42.7	1.7E-03	2.2E-04	41.0
Uruguay	2002	3.0	-3.0	12521.0	44.6	43.8	1.8E-03	2.0E-04	39.6
USA	1975	4.0	1.8	7044.1	39.7	39.4	1.1E-03	1.4E-04	11.3
USA	1980	5.0	2.8	8166.0	40.3	39.7	1.0E-03	1.3E-04	14.7
USA	1985	5.0	1.4	13016.0	41.9	40.3	9.3E-04	1.3E-04	18.2
USA	1990	5.0	2.8	16903.0	42.8	41.9	8.6E-04	1.2E-04	18.2
USA	1997	7.0	1.3	23444.0	40.8	42.8	7.9E-04	1.1E-04	19.3
Venezuela	1987	6.0	-4.0	5700.0	53.5	55.6	4.9E-04	1.0E-04	51.0
Venezuela	1995	8.0	0.7	6300.0	46.8	53.5	8.7E-04	1.1E-04	42.3
Venezuela	1998	3.0	0.0	8510.0	47.6	46.8	1.3E-03	1.3E-04	54.1
Vietnam	1998	5.0	6.6	8939.0	36.1	35.7	.	.	67.1
Vietnam	2002	4.0	2.3	1744.0	36.4	36.1	.	.	87.4
Zambia	1993	3.0	-3.5	973.0	46.2	48.3	4.2E-03	7.2E-04	68.0
Zambia	1996	3.0	-5.6	1056.0	49.8	46.2	5.2E-03	8.1E-04	60.7
Zambia	1998	2.0	2.5	934.0	52.6	49.8	6.0E-03	8.4E-04	73.0

Table A3.4: Robustness of Baseline Threshold Model Estimates; Full Data Set, Control Variables

	(1)		(2)		(3)		(4)	
Threshold ($\hat{\gamma}$)	-5.682		-5.682		-5.682		-5.666	
LM Statistic	51.102		52.202		38.284		43.114	
p-value	0.003		0.009		0.006		0.075	
	HK <=$\hat{\gamma}$	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**
GINI	2.525* (0.072)	-5.290** (0.011)	2.308* (0.055)	-4.816** (0.030)	0.629 (0.698)	-4.629** (0.018)	0.592 (0.703)	-3.889* (0.077)
C	-1.346 (0.881)	31.064*** (0.000)	6.188 (0.309)	30.128*** (0.000)	11.214 (0.246)	35.088*** (0.000)	16.195* (0.066)	36.196*** (0.000)
HK	-0.211 (0.750)	1.073** (0.013)	0.046 (0.941)	0.979** (0.018)	-0.412 (0.573)	1.033** (0.017)	-0.225 (0.736)	0.918** (0.031)
LY0	-0.850** (0.023)	0.595 (0.248)	-1.192*** (0.001)	0.377 (0.471)	-0.813** (0.017)	0.302 (0.563)	-1.095*** (0.001)	-0.153 (0.799)
POP	-0.829** (0.024)	-3.211*** (0.000)	-0.858** (0.015)	-3.220*** (0.000)	-0.864** (0.019)	-3.262*** (0.000)	-0.913** (0.013)	-3.305*** (0.000)
OPEN	0.353 (0.431)	-0.160 (0.704)					0.025 (0.955)	0.274 (0.631)
INF			-0.043*** (0.000)	-0.019 (0.214)			-0.043*** (0.0010)	-0.020 (0.176)
GOV					-1.714 (0.109)	-1.714 (0.129)	-1.870* (0.063)	-2.324 (0.109)
Observations	147	69	147	69	147	69	148	68

Notes: The p-values are reported in the brackets. ***, **, and * indicate significant at 1%, 5%, and 10% respectively. Dependent variable is real per capita GDP growth. Threshold variable is log of human capital to physical capital ratio (HK). In constructing HK, human capital is measured as secondary school enrolment in percent, whereas physical capital is measured as capital stock per worker. Inequality (GINI) is endogenous variable which is instrumented by its lagged value. All other explanatory variables are exogenous and we use their lagged values. This table uses our complete data set of 216 pooled observations.

Table A3.5: Robustness of Baseline Threshold Model Estimates; Less than 5-year Averages, Control Variables

	(1)		(2)		(3)		(4)	
Threshold ($\hat{\gamma}$)	-5.954		-5.954		-5.954		-5.954	
LM Statistic	32.878		42.315		32.709		37.654	
p-value	0.105		0.081		0.230		0.417	
	HK <=$\hat{\gamma}$	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**	**HK<=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**
GINI	7.642** (0.011)	-10.767*** (0.006)	5.417* (0.052)	-13.569** (0.041)	4.620 (0.154)	-12.850** (0.020)	3.146 (0.35)	-10.721** (0.031)
C	-26.546* (0.071)	40.086*** (0.000)	-7.910 (0.537)	46.435*** (0.002)	-0.956 (0.959)	46.826*** (0.001)	0.575 (0.974)	39.009*** (0.010)
HK	-2.137 (0.159)	2.254*** (0.001)	-0.872 (0.547)	2.547*** (0.001)	-1.702 (0.257)	2.370*** (0.000)	-1.124 (0.449)	2.286*** (0.002)
LY0	-1.661 (0.108)	2.786*** (0.010)	-1.537 (0.157)	2.997** (0.041)	-1.375 (0.191)	2.778** (0.011)	-0.893 (0.388)	2.833** (0.024)
POP	-2.275** (0.045)	-1.538 (0.275)	-1.523 (0.252)	-1.536 (0.335)	-2.615** (0.035)	-1.465 (0.366)	-1.690 (0.172)	-1.568 (0.257)
OPEN	0.832 (0.349)	-1.019 (0.345)					1.040 (0.345)	-1.127 (0.454)
INF			-0.044** (0.029)	0.007 (0.755)			-0.026 (0.305)	0.001 (0.976)
GOV					-3.142 (0.170)	-0.807 (0.686)	-3.507 (0.186)	0.402 (0.890)
Observations	32	38	32	38	32	38	32	38

Notes: As for Table A3.4. This table uses data calculated over less than 5-year intervals.

Table A3.6: Robustness of Baseline Threshold Model Estimates; 5-year Averages, Control Variables

	(1)		(2)		(3)		(4)	
Threshold ($\hat{\gamma}$)	-5.902		-5.902		-5.902		-6.004	
LM Statistic	38.229		44.208		49.958		49.004	
p-value	0.165		0.364		0.059		0.395	
	HK <=$\hat{\gamma}$	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**
GINI	3.138** (0.048)	-1.166 (0.550)	2.286** (0.029)	-1.546 (0.401)	0.883 (0.591)	-3.845 (0.115)	-0.297 (0.815)	0.491 (0.886)
C	-13.262 (0.367)	28.084*** (0.001)	0.076 (0.991)	28.664*** (0.001)	2.966 (0.834)	44.886*** (0.000)	20.595*** (0.004)	42.879** (0.015)
HK	-0.593 (0.636)	0.185 (0.693)	-0.606 (0.513)	0.255 (0.412)	-1.008 (0.337)	0.112 (0.737)	-0.274 (0.596)	-0.716 (0.279)
LY0	-0.155 (0.727)	-1.506*** (0.003)	-1.037** (0.033)	-1.473*** (0.002)	-0.046 (0.910)	-1.564*** (0.004)	-0.667* (0.075)	-2.667*** (0.003)
POP	-0.119 (0.738)	-3.356*** (0.000)	-0.169 (0.581)	-3.300*** (0.000)	-0.197 (0.656)	-2.999*** (0.000)	-0.721*** (0.001)	-2.707*** (0.009)
OPEN	0.517 (0.318)	-0.184 (0.806)					0.254 (0.393)	-0.933 (0.317)
INF			-0.043** (0.034)	0.012 (0.724)			-0.023*** (0.001)	-0.138*** (0.008)
GOV					-2.753** (0.019)	-2.708** (0.030)	-3.587*** (0.000)	-4.650** (0.027)
Observations	71	20	71	20	71	20	69	22

Notes: As for Table A3.4. This table uses data calculated over 5-year intervals.

Table A3.7: Threshold Model Estimates using Alternate HK ratio Measure; Full Data Set, Control Variables

	(1)		**(2)**		**(3)**		**(4)**	
Threshold ($\hat{\gamma}$)	-7.881		-7.884		-7.466		-7.583	
LM Statistic	34.029		33.433		27.924		30.432	
p-value	0.040		0.064		0.091		0.411	
	HKBL<=$\hat{\gamma}$	**HKBL >$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL>$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL>$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**
GINI	2.593** (0.039)	-3.303* (0.089)	2.833** (0.017)	-2.753 (0.161)	0.900 (0.478)	1.393 (0.476)	1.292 (0.339)	-5.171 (0.194)
C	-2.046 (0.801)	30.028*** (0.000)	2.785 (0.670)	29.277*** (0.000)	8.930 (0.175)	40.404*** (0.000)	10.405 (0.132)	55.209*** (0.001)
HKBL	-0.055 (0.923)	1.191** (0.011)	0.107 (0.846)	1.177*** (0.009)	-0.173 (0.756)	1.761*** (0.002)	-0.281 (0.603)	1.715*** (0.000)
LY0	-0.683** (0.022)	0.163 (0.729)	-0.948*** (0.001)	0.001 (0.999)	-0.614** (0.015)	-0.892 (0.218)	-0.918*** (0.001)	-0.949 (0.121)
POP	-0.854** (0.014)	-3.331*** (0.000)	-0.919*** (0.005)	-3.245*** (0.000)	-0.954*** (0.006)	-4.084*** (0.000)	-1.078*** (0.002)	-3.621*** (0.000)
OPEN	0.321 (0.416)	-0.001 (0.998)					0.241 (0.516)	2.013 (0.128)
INF			-0.041*** (0.001)	-0.031* (0.083)			-0.040*** (0.002)	-0.025 (0.120)
GOV					-1.481 (0.136)	-5.068*** (0.001)	-1.882* (0.065)	-4.590** (0.030)
Observations	143	66	142	67	169	40	160	49

Notes: The p-values are reported in the brackets. ***, **, and * indicate significant at 1%, 5%, and 10% respectively. Dependent variable is real per capita GDP growth. Threshold variable is log of human capital to physical capital ratio (HKBL). In constructing HKBL, human capital is measured as average years of schooling, whereas physical capital is measured as capital stock per worker. Inequality (GINI) is endogenous variable which is instrumented by its lagged value. All other explanatory variables are exogenous and we use their lagged values. This table uses our complete data set of 209 pooled observations.

Table A3.8: Robustness of Threshold Model Estimates using Alternate HK ratio Measure; Less than 5-year Averages, Control Variables

	(1)		(2)		(3)		(4)	
Threshold ($\hat{\gamma}$)	-7.967		-8.122		-7.967		-8.081	
LM Statistic	29.286		27.183		18.572		26.031	
p-value	0.156		0.256		0.923		0.728	
	HKBL <=$\hat{\gamma}$	**HKBL >$\hat{\gamma}$**	**HKBL <=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL <=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL <=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**
GINI	8.147*** (0.005)	-9.512** (0.015)	1.173 (0.755)	-6.785 (0.119)	5.2565* (0.092)	-10.733** (0.035)	0.226 (0.945)	-4.041 (0.344)
C	-24.492* (0.097)	44.366*** (0.000)	39.599 (0.130)	39.254*** (0.000)	-2.892 (0.871)	49.584*** (0.000)	31.177 (0.194)	29.114** (0.041)
HKBL	-1.387 (0.273)	1.990*** (0.001)	1.991 (0.214)	2.067*** (0.000)	-1.930 (0.213)	2.017*** (0.001)	0.035 (0.979)	1.912*** (0.001)
LY0	-2.027 (0.129)	2.031** (0.039)	-2.599* (0.063)	1.194 (0.169)	-1.715 (0.187)	1.979** (0.041)	-1.977 (0.146)	1.259 (0.114)
POP	-2.314** (0.033)	-2.182 (0.108)	0.050* (0.977)	-2.301* (0.064)	-3.240** (0.017)	-2.108 (0.152)	-1.234 (0.412)	-2.314** (0.035)
OPEN	1.223 (0.209)	-0.673 (0.515)					1.257 (0.308)	-1.643 (0.220)
INF			-0.074*** (0.005)	-0.040** (0.035)			-0.041 (0.129)	-0.042** (0.041)
GOV					-3.818 (0.166)	-0.952 (0.600)	-4.478 (0.159)	1.564 (0.537)
Observations	30	37	27	40	30	37	28	39

Notes: As for Table A3.7. This table uses data calculated over less than 5-year intervals.

Table A3.9: Robustness of Threshold Model Estimates using Alternate HK ratio Measure; 5-year Averages, Control Variables

	(1)		**(2)**		**(3)**		**(4)**	
Threshold ($\hat{\gamma}$)	-8.069		-8.069		-8.069		-8.171	
LM Statistic	53.223		47.666		35.344		48.224	
p-value	0.061		0.302		0.273		0.414	
	HKBL <=$\hat{\gamma}$	**HKBL >$\hat{\gamma}$**	**HKBL <=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL <=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL <=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**
GINI	2.710* (0.061)	0.656 (0.814)	2.708** (0.016)	0.944 (0.731)	1.049 (0.492)	-2.338 (0.443)	-0.016 (0.990)	2.742 (0.511)
C	-8.897 (0.578)	27.033** (0.013)	-0.551 (0.951)	26.365** (0.019)	1.100 (0.943)	41.091** (0.018)	20.176** (0.017)	35.659* (0.081)
HKBL	-0.174 (0.869)	1.242 (0.355)	-0.019 (0.981)	1.224 (0.383)	-0.612 (0.491)	0.436 (0.731)	0.131 (0.793)	0.104 (0.903)
LY0	-0.091 (0.808)	-1.212 (0.215)	-0.686** (0.024)	-1.265 (0.249)	0.094 (0.798)	-1.613 (0.110)	-0.477 (0.129)	-2.530** (0.028)
POP	-0.095 (0.800)	-3.499*** (0.005)	-0.261 (0.384)	-3.569*** (0.002)	-0.203 (0.650)	-2.823** (0.010)	-0.768*** (0.001)	-2.948*** (0.004)
OPEN	0.263 (0.558)	-0.027 (0.967)					0.154 (0.587)	-0.827 (0.426)
INF			-0.040** (0.044)	-0.008 (0.836)			-0.020*** (0.001)	-0.141*** (0.009)
GOV					-2.380* (0.063)	-2.442 (0.194)	-3.2616*** (0.001)	-3.793 (0.137)
Observations	71	19	71	19	71	19	69	21

Notes: As for Table A3.7. This table uses data calculated over 5-year intervals.

Table A3.10: Robustness of Threshold Model Estimates using Alternate HK ratio Measure; Chambers and Krause (2010) Data

	(1)		(2)		(3)		(4)	
Threshold ($\hat{\gamma}$)	-8.515		-8.515		-8.515		-8.515	
LM Statistic	41.318		48.928		25.622		33.935	
p-value	0.014		0.252		0.521		0.801	
	HKBL <=$\hat{\gamma}$	**HKBL >$\hat{\gamma}$**	**HKBL <=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL <=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL <=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**
GINI	-0.045 (0.956)	-6.571*** (0.000)	-0.621 (0.420)	-6.049*** (0.000)	-1.239 (0.136)	-6.208*** (0.000)	-0.786 (0.367)	-6.374*** (0.000)
C	4.866 (0.445)	21.569*** (0.000)	6.565 (0.306)	20.523*** (0.000)	10.167 (0.130)	20.600*** (0.000)	8.770 (0.191)	21.595*** (0.000)
HKBL	0.599 (0.346)	0.874 (0.162)	0.248 (0.701)	0.957 (0.119)	0.268 (0.660)	0.970 (0.126)	0.650 (0.286)	0.807 (0.223)
LY0	0.093 (0.847)	1.349*** (0.010)	0.012 (0.981)	1.507*** (0.001)	0.268 (0.601)	1.536*** (0.001)	0.388 (0.425)	1.305** (0.019)
POP	-0.258 (0.318)	-0.040 (0.791)	-0.221 (0.421)	-0.026 (0.872)	-0.234 (0.371)	-0.013 (0.932)	-0.263 (0.289)	-0.046 (0.759)
OPEN	0.560** (0.044)	0.377 (0.295)					0.638** (0.015)	0.399 (0.348)
INF			0.0002 (0.732)	-0.004 (0.614)			0.0003 (0.381)	-0.003 (0.684)
GOV					-1.317** (0.030)	0.105 (0.893)	-1.427** (0.019)	-0.376 (0.680)
Observations	156	104	156	104	156	104	156	104

Notes: As for Table A3.7. This table uses data which is an extended version of Chambers and Krause (2010).

Table A3.11: Robustness of Baseline Threshold Model Estimates; Full Data Set, Without Log of Threshold Variable

	(1)		(2)		(3)		(4)	
Threshold ($\hat{\gamma}$)	0.003		0.003		0.003		0.003	
LM Statistic	48.260		47.952		49.537		33.525	
p-value	0.011		0.013		0.041		0.064	
	HK <=$\hat{\gamma}$	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**	**HK <=$\hat{\gamma}$**	**HK >$\hat{\gamma}$**
GINI	2.263* (0.069)	-5.841*** (0.006)	2.491* (0.064)	-6.833*** (0.006)	2.315* (0.053)	-4.912** (0.028)	0.562 (0.725)	-4.895** (0.013)
C	3.344 (0.578)	29.464*** (0.000)	1.219 (0.861)	31.187*** (0.000)	6.668 (0.218)	27.759*** (0.000)	15.431 (0.125)	33.144*** (0.000)
HK	-204.517 (0.607)	28.400 (0.148)	-249.842 (0.535)	36.211* (0.063)	-108.302 (0.764)	25.584 (0.173)	-385.940 (0.371)	26.816 (0.177)
LY0	-0.930*** (0.007)	0.218 (0.651)	-0.911*** (0.008)	0.106 (0.828)	-1.269*** (0.000)	0.031 (0.951)	-0.856*** (0.006)	-0.037 (0.940)
POP	-0.792** (0.029)	-3.107*** (0.000)	-0.816** (0.026)	-3.207*** (0.000)	-0.840** (0.016)	-3.114*** (0.000)	-0.851** (0.021)	-3.144*** (0.000)
OPEN			0.310 (0.429)	0.767 (0.184)				
INF					-0.043*** (0.000)	-0.024 (0.151)		
GOV							-1.801* (0.084)	-1.785 (0.119)
Observations	147	69	147	69	147	69	147	69

Notes: The p-values are reported in the brackets. ***, **, and * indicate significant at 1%, 5%, and 10% respectively. Dependent variable is real per capita GDP growth. Threshold variable is human capital to physical capital ratio (HK). In constructing HK, human capital is measured as secondary school enrolment (%), whereas physical capital is measured as capital stock per worker. Inequality (GINI) is endogenous variable which is instrumented by its lagged value. All other explanatory variables are exogenous and we use their lagged values. This table uses our complete data set of 216 observations.

Table A3.12: Robustness of Threshold Model Estimates using Alternate HK ratio Measure; Full Data Set, Without Log of Threshold Variable

	(1)		(2)		(3)		(4)		(5)	
Threshold ($\hat{\gamma}$)	0.0004		0.0004		0.0004		0.0004		0.0004	
LM Statistic	34.323		33.701		37.476		25.225		32.354	
p-value	0.043		0.173		0.028		0.293		0.205	
	HKBL<=$\hat{\gamma}$	**HKBL >$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**	**HKBL<=$\hat{\gamma}$**	**HKBL >$\hat{\gamma}$**
GINI	2.252* (0.051)	-3.691* (0.084)	2.466** (0.041)	-5.573 (0.107)	2.717** (0.018)	-3.229 (0.122)	0.424 (0.752)	-3.020 (0.118)	0.807 (0.535)	-7.108* (0.058)
C	4.554 (0.326)	23.767*** (0.000)	3.182 (0.513)	27.847*** (0.001)	6.168 (0.168)	23.073*** (0.000)	17.499** (0.019)	27.441*** (0.000)	19.461*** (0.006)	40.793*** (0.001)
HKBL	-2694.857 (0.396)	795.567*** (0.000)	-3373.129 (0.302)	854.948*** (0.000)	-2261.129 (0.425)	798.897*** (0.000)	-5139.394 (0.141)	749.048*** (0.000)	-5807.410* (0.078)	870.807*** (0.000)
LY0	-1.042*** (0.000)	0.029 (0.950)	-1.130*** (0.000)	-0.046 (0.921)	-1.343*** (0.000)	-0.087 (0.851)	-0.833*** (0.002)	-0.082 (0.858)	-1.171*** (0.000)	-0.462 (0.302)
POP	-0.858** (0.014)	-3.726*** (0.000)	-0.889** (0.011)	-3.765*** (0.000)	-0.958*** (0.004)	-3.6235*** (0.000)	-0.942*** (0.008)	-3.703*** (0.000)	-1.079*** (0.002)	-3.708*** (0.000)
OPEN			0.385 (0.273)	0.887 (0.326)					0.403 (0.260)	2.355** (0.047)
INF					-0.043*** (0.000)	-0.030* (0.058)			-0.040*** (0.001)	-0.023 (0.143)
GOV							-2.223** (0.027)	-1.801* (0.061)	-2.551** (0.011)	-3.292** (0.021)
Observations	150	59	150	59	150	59	150	59	150	59

Notes: As for Table A3.11. Threshold variable is human capital to physical capital ratio (HKBL). In constructing HKBL, human capital is measured as average years of schooling, whereas physical capital is measured as capital stock per worker.

Thesis Conclusion

In this thesis we address some important issues related to growth, specifically focussing on the finance-growth and inequality-growth relationships. Until recently, the dominant view in the finance-growth literature has been that financial development strongly and positively affects economic growth. However, the recent literature which incorporates the effects of financial innovation, excessive finance and financial crises, shows that the effect of financial development on growth is ambiguous or even becomes negative in the presence of excessive finance and crises. Similarly, despite of significant theoretical and empirical contributions of past studies on the inequality-growth relationship, they do not provide a single framework that could combine the two existing strands of literature: First, shows the positive effects of inequality on growth via physical capital accumulation (*classical approach*). Second, argues that the effect of inequality on growth is negative using the channels of credit market imperfection, political process, and technological innovation etc. (*modern approach*). Galore and Moav (2004) are the first to combine the above two approaches on inequality-growth relationship (*unified approach*) and show that the nature of this relationship is non-linear.

The recent literature has indicated that both the finance-growth and inequality-growth relationships are complex and not well captured through conventional linear regression analyses. Greenwood and Jovanovic (1990) is perhaps the first study that combines these two important strands of literature and predict a non-linear relationship between financial development, income inequality and economic growth. Their model implies that the relationship between growth and income distribution depends on financial development. At the early stage of economic development, the financial intermediaries are not fully developed and only rich can afford and benefit from the services provided by them. Consequently, income inequality across the rich and poor widens. However, at the latter stage of economic development the financial intermediaries are fully developed and many people can afford to join them which results in improved resource allocation, stable distribution of income and high growth as compared to the early stage of development.

Motivated by the recent findings on finance-growth relationship, Chapter 1 investigates the sensitivity of finance-growth regressions using some past cross-sectional data sets and our extended data set for 86 countries over the period 1997-2006. It replicates the analyses of four past studies (Levine and Zervos, 1998; Beck et al, 2000a; Levine, 2002; and Beck and Levine, 2004) which are prominent in the literature: first, using their data sets and techniques; second, using their data sets and two robust regression methods of median quantile regression (QR) and least trimmed squares (LTS). Further, we analyse the specification of Beck and Levine (2004) using our extended data set and robust regression methods (QR and LTS). Overall, the robust analyses of previous studies show that results obtained using most indicators of financial development are sensitive to the presence of outliers, except trading value (TVT), finance efficiency (FE), finance aggregate (FG) which have relatively stable signs and significance. This finding is consistent with the view that the indicators of financial development may possess outliers because these measures are subject to measurement error and may contain the effects of financial bubbles (see Chinn and Ito, 2006). The finding also throws further doubt on the previous view that financial development is positive for growth, since that result largely disappears when robust estimation methods are employed.

The analysis of our extended data set (for 86 countries over the period 1997-2006) which uses the specification of Beck and Levine (2004) shows that OLS estimates employing private credit to GDP ratio (PRIV) and turnover ratio (TOR) are ambiguous. However, after omitting outlier observations, the LTS estimation shows that the effect of PRIV on growth is negative and significant at 10% level, whereas the effect of TOR is negative but insignificant. The above results are consistent with the recent cross-sectional finding of Rousseau and Wachtel (2011) which shows that the different episodes of financial crises have changed the nature of finance-growth relationship and that positive effect of financial development on growth disappears in recent data sets.

Furthermore, when R&D (GERD) is introduced, it is found to play an important role. It has a strong and positive effect on growth, while it may also capture some of the effect of financial development on growth. The latter outcome is suggested by a negative but insignificant effect of PRIV on growth. Further, the magnitude of the coefficient on PRIV decreases from 0.574 to 0.046. Although the coefficient on TOR is still insignificant, it changes its sign. This finding is explored in detail in Chapter 2, where we introduce R&D into a fuller analysis, using it to proxy the role of an omitted variable that be highly correlated with growth and has important interactive effects with the conventionally measured financial development.

Therefore, in chapter 2 we investigate the conditional effects of financial development on economic growth, using innovation or R&D as a conditioning variable. In the light of the recent literature that associates R&D with financial innovation, where the latter may be unregulated and lead to crises (see Gennaioli et al, 2010; Michalopoulos et al, 2010; Ductor and Grechyna, 2011), we use this variable as a proxy and study its interaction with conventionally measured financial development. Our aim is to combine financial development, innovation and growth through two testable hypotheses: first, the relationship between financial development and economic growth is not straightforward, rather it is conditional upon the level of innovation or R&D; and second, a high level of technological innovation or R&D is associated with a weak or negative effect of financial development on economic growth.

We use two measures of financial sector development: finance size (FS) and finance activity (FA), and two measures of R&D activity: R&D intensity (BERDIND) and the number of patent applications (NPATA). Further, we use a multiplicative interaction model to capture the conditional effects of financial development on growth which is estimated by employing three estimation techniques of panel data: two-way fixed effects, difference GMM, and system GMM estimators that take into account the problem of endogeneity and country specific characteristics. We also take care of influential outliers by applying the *Hampel Identifier* to the residuals obtained from each model.

Our regression results show that the marginal effects of financial development and R&D on economic growth are positive and significant. Further, the relationship between financial development and growth is conditional upon the level of R&D; that is, it decreases as the level of R&D increases and even becomes negative at very high levels of R&D. Thus, the negative interaction between financial development and R&D suggests that at a very high level of R&D adding more financial development may not be a growth promoting policy.

We provide two explanations for these findings: first, countries with a very high level of innovation or R&D activities may have highly deregulated financial systems that promote financial innovations to meet the demands of innovators or investors. In this situation adding more financial development is likely to deteriorate credit standards, increase growth of non-performing loans, generate credit booms and increase the probability of bank crises. Consequently, financial crises have an adverse impact on economic growth. In this sense our findings are consistent with the most recent literature (Michalopoulos et al, 2010; Rousseau and Wachtel, 2011). Second, as the sign of our interaction terms is negative it suggests that financial development and innovation are substitutes. Hence growth promoting policies should be directed either to financial sector development or innovation sector. In this sense our results are consistent with the view that any subsidy given to either of the financial and innovation sector is better than if it is given to both (see Morales, 2003). Our study proposes that financial development is more effective in those countries whose investment in R&D, especially industrial R&D, is low. This may be an indication, though not a direct proof, that countries which have high R&D (e.g. Japan, Korea, Turkey, Switzerland, Luxembourg, Finland, etc) may be those where the financial systems are less regulated, specifically in relation to financial innovations, which may cause conventionally measured financial development to lose its effectiveness to promote growth in the economy.

We contribute in the literature of inequality-growth relationship by investigating the effect of income inequality on economic growth through our constructed ratio of human and physical capital in chapter 3. Consistent with the seminal work of Galor and Moav (2004), chapter 3 constructs a new measure of human capital to physical capital ratio (HK ratio) and focuses on the following two questions: first, whether there exists a threshold level of HK ratio above and below which the relationship between inequality and growth changes; second, whether the effect of inequality on growth is positive below the threshold of HK ratio and negative above it.

Our threshold regression estimates show that there exists a significant threshold level of human capital to physical capital ratio below which the effect of inequality on growth is positive and significant, whereas it is negative and significant above it. This result is consistent with the theoretical predictions of Galor and Moav (2004). Further, we observe that the coefficient of human capital to physical capital variable itself remains negative and insignificant below the estimated threshold, whereas it is positive and significant above it. It suggests that in early stage of development (before threshold) human capital is relatively unimportant and the negative coefficient may be due to the dominance of physical capital over the human capital, whereas in later stage of development (after threshold) human capital emerges as a main force behind increases in economic growth. We also show some interesting results related to the convergence literature and the impact of population growth on economic growth. The sign of convergence variable (initial per capita GDP) is negative and significant below the estimated threshold, whereas it is positive and insignificant above it. It suggests that countries with relatively low level of human capital experience significance convergence, whereas it is not there for more developed countries with relatively high level of human capital. Further, the negative and significant coefficient of population growth shows that it is harmful for economic growth, result being consistent with the mainstream literature on population and growth.

Overall, our three chapters document some important results that may be helpful in drawing useful policy conclusions related to finance-growth and inequality-growth relationships. The findings related to finance-growth relationship suggest that the cross-sectional analyses are prone to the problems of outlier observations; hence, robust regression methods may provide us a clearer picture of this relationship. Further, financial development is more effective in countries with relatively low investment in R&D, especially industrial R&D. However, in countries with a very high level of R&D the effect of financial development may be unclear or even negative; the reason may be that in these countries the financial systems are more deregulated and thus prone to financial crisis.

On the other hand, the results of inequality-growth relationship suggest that at the initial stage of development for growth governments may opt the policy of encouraging physical capital accumulation which, consequently, leads to income inequality. The policy makers and analysts should not be alarmed to see this happening as long as their emphasis is on enhancing economic growth. However, they are required to be vigilant about the right time of switching their emphasis from physical capital to human capital. Because, if they are failed to do so they might eventually end up with not only high income inequality but also lower economic growth along with it.

We suggest that the analyses of finance-growth and inequality-growth relationships may be extended in the future research as follows. First, our analysis of chapters 1 and 2 may be extended by performing an in-depth time series analyses for two groups of countries: those which are highly affected by recent financial crisis and those which are less affected or not affected at all. Comparing the findings of these two groups may enhance our understating of the interactive effects of financial development and R&D on growth in the context of financial crisis. Second, there may be need to investigate further the threshold effects of financial development on innovation or R&D which is highly correlated with economic growth. This kind of analysis may help us to know any threshold level of financial development beyond which further financial development may be detrimental for R&D as well as growth, particularly, in the light of recent literature on excess finance and financial crisis.

Third, as unregulated financial innovation may cause conventionally measured financial development to lose its effectiveness to promote growth in the economy; we may explore the threshold effects of financial innovation on finance-growth relationships. Fourth, the inequality-growth analysis may further be extended by using comparable measures of human and physical capital in the construction of our newly introduced measure of human capital to physical capital ratio (HK ratio). Fifth, another way to test the theoretical predictions of Galor and Moav (2004) may be to investigate the effect of financial development on inequality using the channel of human capital to physical capital ratio (HK ratio). To the best of our knowledge no earlier theoretical or empirical study has explored this channel.

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