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Essays on Bank Development, Income Inequality and Human Capital Inequality

A THESIS SUBMITTED TO THE UNIVERSITY OF DUBLIN, TRINITY COLLEGE

IN APPLICATION FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

BY

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Supervised by

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PHD
SOCIAL
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Summary

The core of the thesis consists of three empirical papers. The first one is about the link between bank development, corruption and economic growth. The second and the third both talk about inequality and how it relates to economic development. But the concepts of inequality differ in the two papers. The second one focuses on income inequality, while the third one examines human capital inequality.

Following an introductory chapter that presents the motivation and major findings of the thesis, Chapter 2 investigates how bank development and corruption interactively impact economic growth based on a panel data set on 110 countries for the period 1985-2009. As to the measurement of bank development, this paper looks beyond the traditional size measure of banking system from the literature, private credit to GDP, by including two other bank indicators to capture the depth and efficiency of bank development, which are normally ignored in the empirical analysis. Using one-step system GMM estimation, the results suggest that the size of banking system is negatively related to growth, while the depth and efficiency are both positively linked to growth. Corruption has no direct growth effect. However, its interactions with bank development indicators are significant, suggesting that the role of bank development is more important in corrupt countries. The results also show that the effects differ as corruption level varies. In more corrupt countries, corruption has no direct effect on growth, but works through the bank-growth channel. In particular, the adverse effect of increasing SIZE measure of banking system and the positive effects of increasing bank DEPTH and EFFICIENCY will diminish if corruption control is improved. Within less corrupt countries, bank SIZE is also found to be negatively related to growth. But the adverse effect is alleviated by improvement of corruption control.

Chapter 3 revisits the old research question, which is the impact of income inequality on income level. With no consensus in the literature, this paper attempts to reassess the link based on a new set of instruments, within-country heterogeneity in early development, constructed by Putterman and Weil (2010). Based on the 2SLS estimation, the results confirms within-country heterogeneity in early development to be a strong predictor of current income inequality, and inequality is positively related to current income over the full sample, which is mainly driven by poor countries. In more developed countries, the inequality-income link is

insignificant. Intuitive explanation and various statistical tests support the validity of the new instruments. In addition, various hypotheses are tested to explain the channels through which inequality impacts income. The evidence supports the redistributive median-voter hypothesis that the impact of inequality on income is negative in democratic countries.

Chapter 4 looks into human capital inequality. It assesses the link between human capital inequality and human capital accumulation through two channels, fertility channel and public spending on education channel. To ease endogeneity, the period 1960-2010 is divided into two sub-periods, so that each channel involves two stages and OLS estimations on 90 countries are applied to each stage. The fertility channel predicts a positive link between inequality and fertility rate, which is found to be stronger in more developed countries. Higher fertility rate will then impede human capital accumulation. Moreover, in countries with more credit constraint, the negative impact of fertility on human capital accumulation will be reinforced. The other channel shows that human capital inequality is negatively related to public spending on education. The effect is found to be stronger in more democratic countries. The evidence also confirms that public spending on education will foster human capital accumulation. Therefore, based on the results of the two channels, human capital inequality is found to be negatively related to human capital accumulation.

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To my husband and son

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Chapter 1 Introduction

This thesis mainly covers the following correlates of economic development: bank development, corruption control and inequality. In particular, Chapter 2 looks into the interactive effect on economic growth of bank development and corruption control. Chapter 3 focuses on income inequality and studies how it explains differences in income level across countries based on a new set of instruments. Chapter 4 focuses on human capital inequality and its impact on human capital accumulation.

Recently the relationship between financial development and economic growth has been one of the most important topics in applied economics, both theoretically and empirically. Theoretical works agree that financial system should influence resource allocation and economic growth through the five functions of financial intermediary: acquiring information about investments and allocating resources, monitoring firms and exerting corporate control, facilitating risk amelioration, mobilizing savings, and facilitating exchange. However, there is a gap between theoretical and empirical studies, as empirical analysis usually only captures bank development by size measure, ignoring other functions and measures. It raises our concern that it may lead to unreliable and even misleading conclusions on the importance of bank development. Chapter 2 contributes to the empirical literature by looking beyond the tradition size measure of bank development and including other two indicators to measure depth and efficiency of banking system. In addition, it also considers how corruption plays the role individually and together with bank development. The motivation to take into account corruption is as follows. If corruption exists in government, due to bribe needs, it may increase the need for external finance of private firms, which need government loans or licenses to do business, thus related to banking system. If corruption is embedded in financial sector, it will distort the functioning of banking system by preventing funds going to the most productive and promising entrepreneurs and thus harmful to growth. So it is an interesting and reasonable attempt to combine the two potentially related growth determinants. Applying one-step system GMM estimation to a panel data of 110 countries for the period 1985-2009, the results suggest that the size of banking system is negatively related to growth, while the depth and efficiency are both positively linked to growth. Corruption has no direct growth effect. However, its interactions with bank development indicators are significant. The results also show that the effects differ as corruption level varies. It predicts that the role of bank

development is more important in corrupt countries. In particular, in more corrupt countries, the adverse effect of increasing SIZE measure of banking system and the positive effects of increasing bank DEPTH and EFFICIENCY will diminish if corruption control is improved. Within less corrupt countries, bank SIZE is also found to be negatively related to growth. But the adverse effect is alleviated by improvement of corruption control.

The debate on how income inequality affects income is still going on and no consensus has been reached. One of the challenges in cross-country analysis is to use valid external instruments to assess the causal link from inequality to economic development. Inspired by a hypothesis of Putterman and Weil (2010), Chapter 3 attempts to reassess the impact of inequality on economic development based on new instruments. In their paper, Putterman and Weil (2010) construct variables, called heterogeneity in early development, which measures within-country variations of early development levels by accounting for population movement and composition in each country. I will use them as the new instruments and the validity of the new instruments will be justified both intuitively and statistically. Based on the 2SLS estimation, our results confirms within-country heterogeneity in early development to be a strong predictor of current income inequality, and inequality is positively related to current income over the full sample, which is mainly driven by poor countries. In more developed countries, the inequality-income link is insignificant. In addition, various hypotheses are tested to explain the channels through which inequality impacts income. The evidence supports the redistributive median-voter hypothesis that the impact of inequality on income is negative in democratic countries.

The importance of human capital inequality has been highlighted recently. For instance, the World Bank's world development report of 2006, "Equity and Development", moved for the first time beyond the question of income distribution, to emphasizing inequalities in key opportunity dimensions, including education. So this chapter attempts to contribute to this new yet important topic, focusing on the effect of distributional dimension of human capital. In particular, it is to investigate if human capital inequality has a significant impact on economic development through human capital accumulation. Most importantly, we are interested in the channels through which human capital inequality may influence human capital accumulation. Two channels are discussed, the fertility channel and public spending channel. The fertility channel predicts a positive link between inequality and fertility rate, which is found to be stronger in more developed countries. Higher fertility rate will then

impede human capital accumulation. Although existing studies find out that credit constraint plays an important role in the link between human capital inequality and human capital accumulation, they do not specify the channels through which it works. This paper suggests that it works solely through the fertility channel by reinforcing the negative effect of fertility on human capital accumulation when a country has a constrained access to financial market. The other channel shows that human capital inequality is negatively related to public spending on education. To my best knowledge it is the first time that the channel is proposed to explain the link between human capital inequality and human capital accumulation. The effect is found to be stronger in more democratic countries. The evidence also confirms that public spending on education will foster human capital accumulation. Therefore, based on the results of the two channels, human capital inequality is found to be negatively related to human capital accumulation.

Chapter 2 Bank Development, Corruption and Growth

2.1 Introduction

The importance of financial development, particularly bank development and its relationship with economic growth have recently been emphasized by economists and policy-makers, while corruption is an age-old problem. As a matter of fact, corruption may play an important role in the bank-growth link. If corruption exists in government, due to bribe needs, it may increase the need for external finance of private firms, which need government loans or licenses to do business, thus related to banking system. If corruption is embedded in financial sector, it will distort the functioning of banking system by preventing funds going to the most productive and promising entrepreneurs and thus harmful to growth. So it is an interesting and reasonable attempt to combine the two potentially related growth determinants and this paper is to investigate how the two factors, bank development and corruption, interactively related to economic growth.

Given that empirical studies give ambiguous and weak conclusion on finance-growth link, this paper contributes by questioning the traditional measure of bank development and justifying the necessity and importance of enriching the measurement. In line with the literature, the traditional measure of bank development, private credit to GDP, is included and is denoted by SIZE measure of banking system. The results indicate that empirical tests relying solely on the SIZE indicator may lead to unexpected and misleading conclusion that bank development is harmful to economic growth. The other two measures of bank development, private credit to deposit, which is denoted by DEPTH indicator and net interest margin, which is denoted by EFFICIENCY indicator, are able to capture bank development in different angles and should be considered in empirical studies of bank-growth relationship. Compared to the voluminous works in finance-growth and corruption-growth links separately, few pays attention to their interaction effect. This paper empirically investigates the interaction effect. In addition, I will divide the full sample into two subsamples according to corruption level and test whether the effects differ in subsamples.

Applying one-step system GMM estimation to a panel data of 110 countries for the period 1985-2009, the paper suggests that bank development and corruption interactively affects economic growth. The main findings of the paper are as follows. Firstly, SIZE measure of

banking system is found negatively related to economic growth, insignificant in full sample and significant in both subsample results, while bank DEPTH is mostly significantly and positively related to growth, especially in more corrupt countries. Bank EFFICIENCY is also beneficial to economic growth, but its effect is not significant in full sample. The negative or insignificant link between SIZE and growth is consistent with the evidence in some empirical finance-growth literature¹. Therefore the results suggest that when assessing the bank-growth link, only looking at the SIZE indicator, which is the common strategy in most empirical bank-growth literature, is a potential problem. It overstressed the importance of one aspect of banking development by neglecting others, which are empirically proved to be at least as important as SIZE measure. Secondly, bank development plays a more important role in more corrupt countries, with greater growth effect in more corrupt countries. Corruption has no direct effect on growth in more corrupt countries, but works through the bank-growth channel. More specifically, the adverse effect of increasing SIZE measure of banking system and the positive effects of increasing bank DEPTH and EFFICIENCY will diminish if corruption control is improved. In less corrupt countries, bank SIZE is also found to be negatively related to growth. But the adverse effect is alleviated by improvement of corruption control.

The answer to the research questions above certainly has important policy implications. On one hand, as bank development has multiple dimensions that have different growth effects, policymakers should avoid just expanding the SIZE of bank system while ignoring improving its DEPTH and EFFICIENCY. On the other hand, if the impacts on growth of bank development and corruption are independent, policymakers can choose to develop either of them which bring larger benefit with less cost. However, the findings of the paper indicate a more complicated relationship, as the growth impact of bank development depends on the level of corruption. Policymakers may be cautious making decisions. To guarantee a positive effect from improving bank system, policymakers might want to consider the level of corruption to make sure the level of the corruption control has reached a threshold given the interaction effect exists.

The rest of the paper is organized as follows. Section 2.2 reviews the existing research on the question we are addressing and how it relates to our work. Section 2.3 introduces the data and shows the descriptive statistics. Section 2.4 proposes the empirical models and discusses the

¹ See Rousseau and Wachtel (2005, 2011)

econometric methods. Section 2.5 presents the empirical results and economic significance. Section 2.6 is the robustness check and section 2.7 concludes.

2.2 Related literature

2.2.1 Finance-growth literature

Recently the relationship between financial development and economic growth has been one of the most important topics in applied economics, both theoretically and empirically². Theoretical works support that financial system should influence resource allocation and economic growth through the five functions of financial intermediary (Levine, 2005). These functions are: acquiring information about investments and allocating resources, monitoring firms and exerting corporate control, facilitating risk amelioration, mobilizing savings, and facilitating exchange. Most theoretical literature on the finance-growth nexus attempts to capture one or more functions by combining the endogenous growth theory and microeconomics of financial system. For example, Greenwood and Jovanovic (1990) formally models the dynamic interactions between finance and growth in which financial intermediaries that produce better information on firms will fund more promising firms and induce a more efficient allocation of capital. Another influential work Diamond (1984) develops a model in which financial intermediaries improve corporate governance.

However, the concept of financial development is so complex that there is no precise measurement for each function of financial system at the country level. The complexity of financial system stems from various aspects. On one hand, financial system consists of financial intermediaries including banks, capital market including stock and bond market and etc. Each part of the system has their own functions and therefore their own measurements. On the other hand, for each part of financial system, there are different dimensions. Taking stock market as an example, a large stock market measured by capitalization does not necessarily imply an active and liquid one measured by turnover ratio. A country could have a large but inactive stock market or a small but active stock market. So an indicator measuring one aspect does not necessarily represent the development of the other aspects of the system. Therefore, due to the limit of direct measurement for each of the functions, it is impossible to directly test the link between individual functions and growth empirically. Empirical studies of the finance-growth nexus have in the past examined the impact of the financial sector on

² Levine (2005) has provided comprehensive reviews.

economic growth by using broad proxies of financial sector development, which are mostly size indicators. So it is necessary to distinguish different dimensions of financial development in order to comprehensively understand the relationship with economic growth. In this paper, we only focus on banking system. One of the main functions of banks is to mobilize deposits from savers and disburse credits to investors. Our measures of banks different from existing literature are based on the credit disbursal and resource allocation functions, as well as its efficiency performing these functions.³

Empirical literature, particularly cross-country analysis gives mixed evidence on finance-growth link. An extensive empirical literature found positive relationship between financial development and economic growth (see Demirgüç-Kunt and Maksimovic, 1998; Levine et al., 2000; Rousseau and Syllab, 2005). However, others found contradictory evidence on the finance-growth link. In particular, they fail to find significant and positive relationship between financial development and economic growth. The different results may be due to many factors, such as measurement, estimation strategies, time periods, sample selection, etc. For example, De Gregorio and Guidotti (1995) presented evidence of a negative effect on growth in a sample of 12 Latin American countries during 1950-1985. More recently, several studies questioned the positive link and found a possible negative relationship. Rousseau and Wachtel (2011) found that the impact of financial deepening on growth is not as strong with more recent data as it appeared in the original panel studies with data for the period from 1960 to 1989. In more recent period, the indicator of financial development has significant and negative coefficient. Arcand et al. (2015) shows that the effect of financial development is no longer significant when credit to the private sector reaches 42% and becomes negative when the index is at 90%. It supports my finding that the SIZE measure is found to be negatively related to growth over the full sample, as almost half of the observations have reached the 42% threshold. Ceccetti and Kharroubi (2015) examined the negative relationship between the rate of growth of the financial sector and the rate of growth of total factor productivity, which arises from the fact that investment projects that are easier to pledge as loan collateral have lower productivity. As the financiers improve their ability to recover collateral in default, entrepreneurs expect credit to grow more quickly. Therefore they choose to invest in more

³ It is also one of the limitation of the paper. We capture and focus only on some main functions of banks. As to other functions, like corporate control and risk amelioration, the paper fails to capture them.

pledgeable and less productive projects, reducing total factor productivity growth. Their data shows that financial growth disproportionately harms industries the less tangible their assets or the more R&D intensive they are.

As one of the few works that deviate from traditional finance-growth analysis, Beck, Degryse, and Kneer (2012) also calls for the need to challenge the traditional measure of financial development. They tackled with the problem from a different angle from ours. They attempted to discriminate between the impact of intermediation and non-intermediation activities provided by the financial sector to capture the extent to which the financial industry performs its function as an intermediary between borrowers and lenders. While our paper contributes to the finance-growth debate by broadening the traditional measures of bank development, confirming that the SIZE of banking system is negatively related to growth and showing that the other aspects of bank development are also important in terms of the impacts on growth and should be included in empirical analysis of finance-growth link.

2.2.2 Corruption-growth literature

There is a strand of literature focusing on the link between corruption and growth. In the theoretical literature, the debate on the effect of corruption has led to two opposing directions. For example, Shleifer and Vishny (1993) and Murphy et al. (1993) argues that corruption may be costly to economic development because it distorts the allocation of resources (as talent and effort will be allocated to rent-seeking) and discourages entry of innovative firms (as innovators are often credit-constrained and could not pay bribes). On the contrary, Acemoglu and Verdier (1998) shows that the presence of corruption may be part of an optimal allocation in the presence of incomplete contracts and incentive problems. Corruption may induce a more efficient provision of government services by providing a leeway for entrepreneurs to bypass inefficient regulations. Evidence from micro and case study tends to support one of the theoretical predictions that corruption retards economic growth (Fisman & Svensson, 2007; Rand & Tarp, 2012; Reinikka & Svensson, 2005). However, macro evidence is inconclusive. Strong negative correlations exist between corruption measures and economic development in some works, such as Gould and Amaro-Reyes (1983), Del Monte and Papagni (2001), Nations (1990), Tanzi and Davoodi (2000) and Rahman, Kisunko, and Kapoor (2000). Other evidence leads to another story. Mauro (1995) is the first attempting to study the corruption-growth link in a large cross-section of countries. Although a broader measure of bureaucratic efficiency is correlated with investment and growth, he does not find

robust evidence of a link between corruption and growth, which is also stressed and supported by Svensson (2005). The findings of this paper seem to indicate the coexistence of positive and negative effect of corruption on growth, as the effects differ in various country groups.

2.2.3 Literature on financial development, institutional quality and growth

Compared to the works mentioned above, fewer works investigate how financial development and institutional quality interactively relate to economic growth. In this context, Claessens and Laeven (2003) suggest that in countries with more secure property rights, firms might allocate resources better and consequently grow faster as the returns on different types of assets are more protected against competitors' actions. In terms of corruptions as a specific component of institutional quality, Beck, Demirgüç-Kunt, and Maksimovic (2005) find out that the growth benefit from improving financial system is hindered by the increase in the levels of corruption. It is in line with the finding of Brunetti, Kisunko, and Weder (1997) that corruption is ranked ahead of the financial constraints and therefore financial development and its growth benefit is determined by the corruption level. Demetriades and Hook Law (2006) find that financial development has larger effects on GDP per capita when the financial system is embedded within a strong institutional framework, where corruption enters as one of the institutional quality indicators. So among those few works dealing with bank development and institutional quality together, the results are rather consistent, pointing to the fact that lower level of institutional quality hinders the growth effect of improving banking system. However, the very few studies dealing with the role of corruption or general institutional quality in finance-growth nexus are far away from comprehensive analysis, thorough investigation and conclusive results. On one hand, most of them focus on general institutional qualities and do not distinguish different institutions. Particularly, either is their interest not corruption but general institutional quality, or did they fail to provide robustness of the effect of corruption given that there is high correlation between corruption and other institutional quality indicators. On the other hand, they did not provide evidence to support the effect of corruption on bank-growth link differs in countries with different corruption levels. So our work contributes to the few works relating bank development, corruption and growth by not only broadening the measure of banking system, but also focusing on corruption and providing robust results.

2.3 Data

2.3.1 Measure of bank development and corruption control

Empirical studies of the finance-growth nexus have in the past examined the impact of the bank system on economic growth by using broad proxies of banking development, which are mostly size indicators. Private credit/GDP, which equals the value of credits channelled by financial intermediaries to private sector divided by GDP, is one of the most frequently used indicators. Its popularity may be partly due to the fact that it excludes credit issued to governments, governments' agencies, and public enterprises and at the same time it excludes credit issued by the central bank and development banks. In other works, whose interest is the overall measurement of financial system, their indicator is the ratio of private credit by deposit money banks and other financial institutions. Since I am interested in the banking system, I look at private credit by deposit money banks to GDP, excluding other financial institutions.

There are several reasons why we follow the finance-growth literature and use this indicator as measure of banking development. Firstly and intuitively it is a direct and general measure of one of the most important functions of banking system, which is to acquire information about investments and allocate resources to most productive sectors, i.e. private sector. Financial systems that allocate more credit to the private sector are more likely to be engaged in researching borrower firms, exerting corporate control, providing risk management control, facilitating transactions, and mobilizing savings (Levine, 2005), which requires a higher degree of financial development. Second, by following the traditions of existing literature, we are able to compare the results with others, which is an important part of the research by contributing to empirical finance-growth literature with mixed evidence. In the rest of the paper, we will call it SIZE indicator of bank development.

One of the innovations of the study is to look beyond the traditional proxy of bank development, since the SIZE indicator alone cannot capture the functioning of banking system comprehensively. From the definition, the SIZE indicator indeed only measures how much banks allocate resources relative to the size of the economy. As to the other functions of banks, such as mobilizing saving from depositors and facilitating exchange, they are not reflected in the indicator. Therefore, we need to introduce other measures to capture to what extent and how well banks operate these functions.

Another indicator introduced is private credit to deposit ratio, which is the ratio of claims on the private sector to deposits in deposit money banks. We call it the DEPTH indicator in the rest of the paper. The difference from the size indicator is that it is a ratio to deposits instead of GDP. It gauges the extent to which banks funnel credit to the private sector from its own deposits. Compared to the size indicator, it captures another important function of banks, which is to mobilize savings from depositors. Therefore, the depth indicator directly measures two main functions of banks together, mobilizing saving and allocating resources. Differing from the SIZE indicator, which can be seen as an external and relative measure of the size of banking system, the DEPTH indicator focuses on banking system itself and can be seen as an internal measure of banking system.

Another indicator is net interest margin, which is the accounting value of a bank's net interest revenue as a share of its total earning assets. The margin is widely considered, and often used, as a proxy for the efficiency of financial intermediation (Demirgüç-Kunt & Huizinga, 1999). So we call it EFF indicator. In a neoclassical model where there are no market frictions, deposit and lending rates should be approximately equal. However, market frictions, such as intermediation costs associated with screening and monitoring due to information asymmetries and regulatory inefficiencies (Stiglitz & Weiss, 1981), as well as processing savings and payment services drive a wedge between the interest rate paid to savers and the interest rate charged to borrowers. Margins are also a function of a country's laws and institutions (Bae and Goyal, 2009; Demirgüç-Kunt et al., 2004; Laeven and Majnoni, 2005; Qian and Strahan, 2007). Countries with lower net interest margins have more efficient and competitive banking system, and less deadweight loss for savers and borrowers. A wider spread reduces the demand for loans and investments, thus lowering economic development. Therefore the efficiency measure should have an impact on economic performance (Wurgler, 2000).

In sum, the following regression exercise is based on the three indicators measuring three different aspects of banking system. The first is a proxy for the bank development relative to the whole economy, which is measured by private credit/GDP and denoted by SIZE. The second measures the extent to which banks funnel credit to the private sector by utilizing the deposits, which is measured by private credit/deposit and denoted by DEPTH. The third measures the efficiency of the banking system, which is measured by net interest margin and denoted by EFF. All of them are from the World Bank's Financial Development and Structure Database (FDSD). This database provides a comprehensive and unique list of annual indicators

to capture financial development and structure across a large number of countries and over time along many different dimensions, starting from 1960.

The country level corruption index is from International Country Risk Guide (ICRG), which is scaled from 0-6. Higher values imply stronger corruption control, and vice versa. Therefore, we denote the index by Corruption Control in the following tables. This is an overall assessment of corruption in the form of excessive patronage, nepotism, job reservations, 'favor-for-favors', secret party funding, and suspiciously close ties between politics and business within the political system.

We analyse the link between bank development, corruption and economic growth in a panel of 110 countries. Data are averaged over five 5-year periods between 1985 and 2009 instead of annual data in order to ease the issue of business cycles. The dependent variable is the growth rate of real GDP per capita over each 5-year period. In line with Levine and Renelt (1992) and Beck and Levine (2004), I have controlled for several potential determinants of economic growth in our regressions. Initial income (denoted by Initial), which is real GDP per capita in the beginning year of each period, is to control for convergence, and the average years of schooling (denoted by Education) is to control for human capital accumulation. Other variables are also controlled for, including total government expenditures to GDP (denoted by Government), the share of exports and imports to GDP (Trade), the inflation rate (denoted by Inflation). They are all directly cited from or calculated based on World Development Indicators (WDI) of the World Bank.

2.3.2 Summary statistics

Summary statistics of the three bank indicators, corruption index, and dependent variable GDP per capita growth for the cross-sectional and 5-year panel dataset are respectively displayed in Table 2.1 and Table 2.3. On average bank SIZE accounts for about 43% of a country's GDP. DEPTH is dispersed around a mean of 0.97 and EFF of 0.05. The SIZE averages of Sierra Leone, Uganda and Yemen Republic, which are less than 6%, are smallest suggesting that the overall scale of banking is relatively insignificant in these countries. The opposite is the case in Hong Kong, Japan and Switzerland where country averages are largest. However, the averages of DEPTH of Hong Kong and Japan, which are both around 0.75, are below average. It again highlights the importance of going beyond traditional measures of bank development. Table 2.2 and Table 2.4 show pairwise correlation coefficients. The correlations between three bank

indicators are mostly significant and with expected signs⁴, however the magnitude is consistently much smaller in panel data. Another interesting observation from the correlation tables is that the significant and positive relationship between growth and corruption identified in cross-sectional data becomes insignificant and negative in panel data. Further evidence in the next sections will support this finding and potential explanations will be discussed below.

Table 2.1 Summary statistics for cross-sectional data, 1985-2009

	Obs	Mean	Std. Dev.	Min	Max
Growth	110	0.02	0.01	-0.02	0.06
SIZE	110	0.43	0.33	0.04	1.50
DEPTH	110	0.97	0.34	0.23	1.95
EFF	110	0.05	0.03	0.01	0.15
Corruption Control	110	3.19	1.19	1.12	6.00

Note: Growth is the average growth rate of real GDP over the period 1985-2009. The annual growth rate is calculated as the annual difference in the logarithm of real GDP per capita. SIZE is private credit/GDP, which is ratio of claims on the domestic private sector by banks to GDP averaged over 1985-2009. DEPTH is private credit/deposit, which is ratio of claims on the private sector to deposits in deposit money banks averaged over 1985-2009. EFF is net interest margin, which is the accounting value of a bank's net interest revenue as a share of its total earning assets averaged over 1985-2009. Corruption Control is overall assessment of corruption, scaled from 0 to 6 averaged over 1985-2009. Initial income is the logarithm of real GDP per capita in 1985.

Table 2.2: Pairwise correlations for cross-sectional data, 1985-2009

	Growth	SIZE	DEPTH	EFF	Corruption	Initial
Growth	1					
SIZE	0.37***	1				
DEPTH	0.23**	0.34***	1			
EFF	-0.35***	-0.62***	-0.14	1		
Corruption Control	0.26***	0.72***	0.35***	-0.48***	1	
Initial Income	0.28***	0.72***	0.32***	-0.54***	0.75***	1

Note: As in Table 2.1; ** p<0.01, * p<0.05, * p<0.1

⁴ Except for the correlation between DEPTH and EFF in cross-sectional data, all other correlations of each pair of the bank indicators are all significant, at least at 0.05 significance level.

Table 2.3: Summary statistics for panel data, 1985-2009 (5-year window)

	Obs	Mean	Std. Dev.	Min	Max
Growth	410	0.02	0.02	-0.12	0.10
SIZE	410	0.50	0.42	0.02	1.93
DEPTH	410	0.96	0.42	0.10	3.05
EFF	410	0.05	0.03	0.01	0.22
Corruption Control	410	3.22	1.29	0.64	6

Note: Growth is the growth rate of real GDP averaged over non-overlapping 5-year windows for the period 1985-2009. The annual growth rate is calculated as the annual difference in the logarithm of real GDP per capita. SIZE is private credit/GDP, which is ratio of claims on the domestic private sector by banks to GDP. DEPTH is private credit/deposit, which is ratio of claims on the private sector to deposits in deposit money banks. EFF is net interest margin, which is the accounting value of a bank's net interest revenue as a share of its total earning assets. Corruption Control is overall assessment of corruption, scaled from 0 to 6. All bank indicators and corruption index are averaged over non-overlapping 5-year periods. Initial income is the logarithm of real GDP per capita of the initial year of each 5-year period.

Table 2.4: Pairwise correlations for panel data, 1985-2009 (5-year window)

	Growth	SIZE	DEPTH	EFF	Corruption Control Control	Initial Income Income
Growth	1					
SIZE	0.13**	1				
DEPTH	0.15***	0.49***	1			
EFF	-0.28***	-0.56***	-0.25***	1		
Corruption Control	-0.02	0.55***	0.32***	-0.40***	1	
Initial income	0.09*	0.70***	0.38***	-0.52***	0.70***	1

Note: As in Table 2.3; *** p<0.01, ** p<0.05, * p<0.1

The scatter plots intuitively display the simple correlations between banking indicators and growth for cross-sectional data. Figure 2.1 to Figure 2.3 show that countries with larger bank SIZE and DEPTH and smaller EFF indicators⁵ tend to have higher long-run economic growth. However, the link between bank SIZE and growth does not hold if shorter time windows are considered and more rigid analysis is carried out in the following sections.

There is a substantial variation of bank development across the sample. For example, in the most recent period, private credit/GDP is more than 80% in Belgium, Ireland, the United States and Hong Kong, while it is less than 10% in Cameroon, Sudan, Libya and Uganda. Algeria, Libya and Malawi have private credit/deposit smaller than 50%, while Denmark, Ireland and Sweden have it larger than 200%. As to EFF indicator, Luxembourg has net interest margin smaller than 1%, while the margin is larger than 10% in Haiti.

⁵ Smaller EFF indicator means more efficient and competitive bank system.

In addition, there is evidence supporting that the three different bank indicators capturing different aspects of bank development, since there is potential divergence between the three indicators, which highlights the importance of going beyond traditional measures of bank development. For example, the SIZE indicator for Botswana averaged over the full period is 14%, similar with that of Romania, which is 16%. Their bank systems are both less developed from the perspective of SIZE indicator. However, their DEPTH levels differ. It is 149% in Romania, more than doubles of Botswana, which is 61%. So in terms of DEPTH indicator, Romania has a more developed bank system than Botswana. Cyprus and Luxembourg also share the same level of SIZE, which is 116%, however, Luxembourg, with EFF indicator 0.8%, is more efficient than Cyprus, whose EFF indicator is 4.8%.

Figure 2.1: Growth and bank SIZE

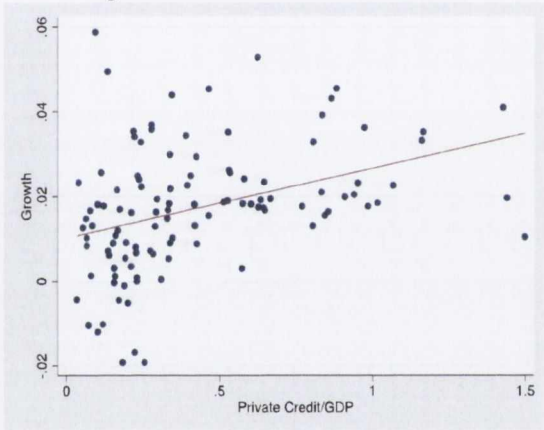


Figure 2.2: Growth and bank DEPTH

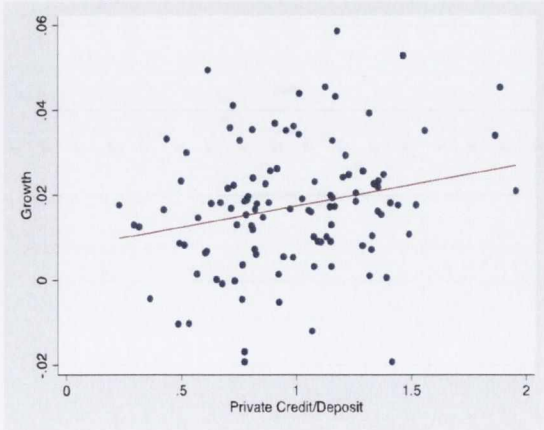


Figure 2.3: Growth and bank EFF

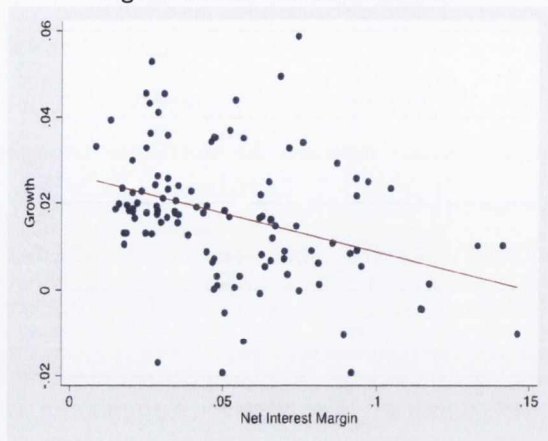


Figure 2.4 to Figure 2.6 show the developments of SIZE, DEPTH and EFF over time in the Netherlands, Turkey and Bolivia. These three figures not only illustrate the potential divergence between SIZE, DEPTH and EFF, but also present substantial variations across time for each indicator, which support the necessity of exploiting both cross-country and cross-time variations in the data. In Netherlands, for instance, from 1988 to 1997, SIZE and DEPTH both increased steadily approximately at the same pace, while from 2000 to 2009, the increase rate of SIZE is larger than that of DEPTH. Through the whole period, the change of EFF, which is more volatile, is not simultaneous with that of the other two indicators. In Turkey, EFF indicator spiked from 0.05 to 0.17 and DEPTH shrank from 0.80 to 0.55 from 1990 to 1994, while SIZE stayed around 0.13. From 1994 to 1999, Bolivia witnessed a steady improvement in SIZE, while DEPTH first deteriorated and then climbed up.

Figure 2.4: Evolution of SIZE, DEPTH and EFF in Netherlands

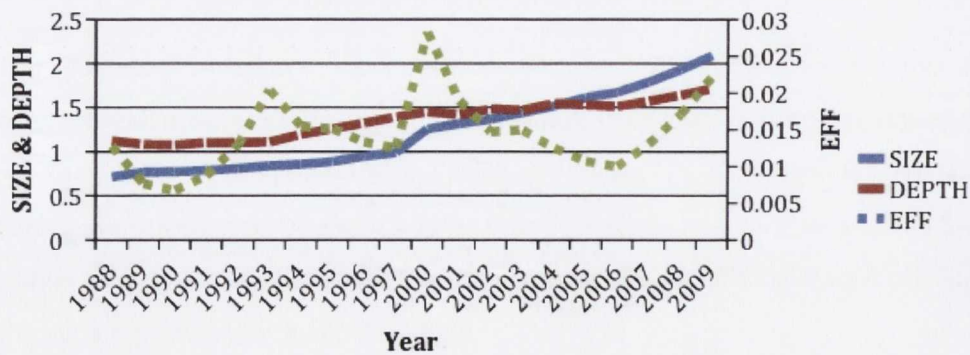


Figure 2.5: Evolution of SIZE, DEPTH and EFF in Turkey

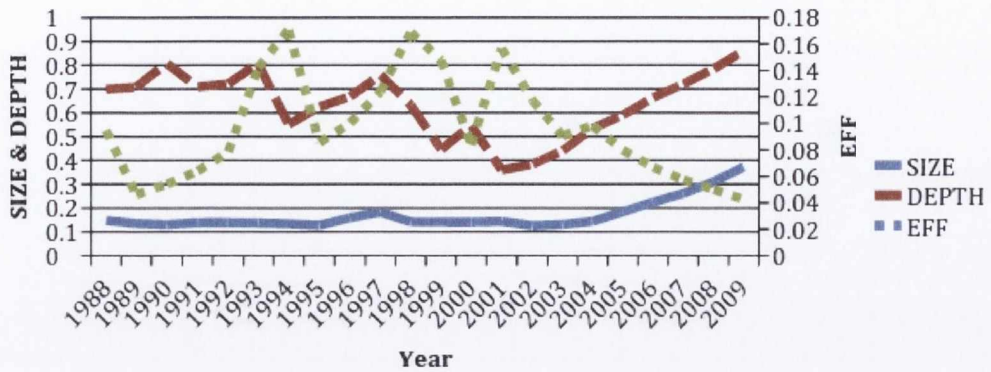
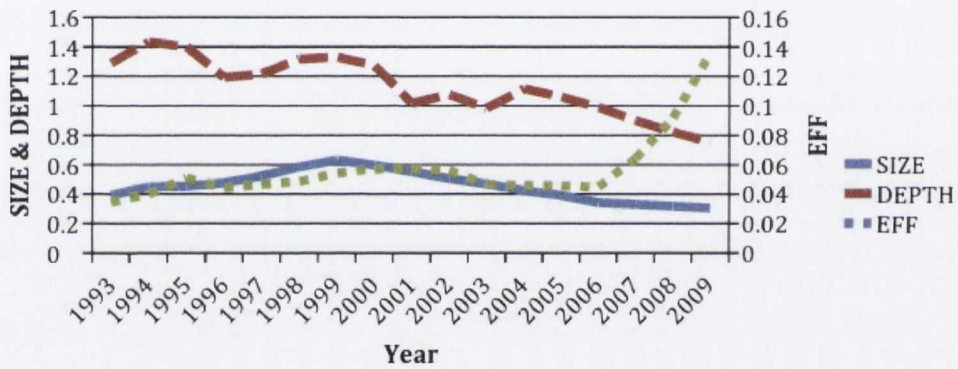


Figure 2.6: Evolution of SIZE, DEPTH and EFF in Bolivia



There is also a wide variation in corruption index. If we also look at the situation in the most recent period, corruption is most severe in Kenya with index less than 1 and is well under control in countries like Canada, Denmark and Finland with index larger than 5. Countries with similar level of bank development may not have the similar level of corruption control. For example, Botswana and Indonesia have similar level of bank SIZE in period 2000-2004, 16.5% and 18.7% respectively, but their corruption levels differ. Botswana is less corrupt with the value of 3 and Indonesia is more corrupt with the value of 1.2.

Real per capita GDP growth also exhibits considerable cross-country variation. For instance, over the recent period, Armenia, Kazakhstan and Latvia enjoyed more than 7% growth rate, while Bahrain, Haiti and Côte d'Ivoire all suffered negative growth rate. Thus, the data provides rich cross-country and cross-time variation for exploring the link between banking development, corruption and economic growth.

2.4 Empirical model and estimation strategy

Different from existing literature, we investigate the relationship between bank development, corruption and growth by including various aspects of banking system in our regression model. We start with a simple model, called Model 1, to assess the growth effects of bank development and corruption.

Model 1

$$\Delta y_{it} = \alpha + \beta_1 y_{it-1} + \beta_2 SIZE_{it} + \beta_3 DEPTH_{it} + \beta_4 EFF_{it} + \beta_5 Cor_{it} + \gamma' X_{it} + (\eta_i + \delta_t + \varepsilon_{it})$$

In the panel there are at most 110 countries that are analysed over a periods of 5 non-overlapping 5-year periods. The first candidate for estimation strategy is pooled OLS. But OLS estimator is inconsistent, since the explanatory variables, particularly the lagged dependent variable, are positively correlated with the error term due to the presence of the individual effects, and this correlation does not vanish as the number of individuals gets larger. If the other explanatory variables are also correlated with the individual effects, which are quite likely in the model, the inconsistency again exists. The Within Group estimator is able to remove individual effects in the transformed equations. However, the transformation at the same time induces a non-negligible correlation between the transformed lagged dependent variable and the transformed error term, which again leads to inconsistent estimator. The Within Group estimator, which introduces all realisations of the shock series into the transformed error term, is only consistent in large N and fixed T panels if all the right-hand side variables are strictly exogenous which does not suit our model here.

Static panel estimates as well as other OLS models omit dynamics causing the problem of dynamic panel bias (Bond, 2002; Baum, 2006) and as such do not allow us to study the dynamics of adjustment (Baltagi, 2008). There are more countries than years in my data, and many authors argue that the dynamic panel model is specially designed for a situation where "T" is smaller than "N" in order to control for dynamic panel bias (e.g. Bond, 2002; Baum, 2006; Roodman, 2006; Sarafidis et al., 2006; Roodman, 2009; Baltagi, 2008). The problem of potential endogeneity is also much easier to handle in the dynamic panel models than in the static and OLS models that do not allow the use of internally generated instruments. GMM estimator is useful when the model contains endogenous or predetermined explanatory variables, but the processes generating them are not completely specified. Under this

circumstance, underlying advantage of the dynamic GMM estimation is that all variables from the regression that are not correlated with the error term (including lagged and differenced variables) can be potentially used as valid instruments, which leads to consistent parameter estimates. It is quite useful especially when valid external instruments are not available, which is the case here.

Finally, after identifying the dynamic panel model as the most appropriate econometric technique for the estimation, we need to choose between “difference-GMM” (henceforth DGMM) developed by Arrelano and Bond (1991) and, “system-GMM” (henceforth SGMM) estimation established by Arrelano and Bover (1995) and Blundell and Bond (1998). First, the SGMM estimate has an advantage over DGMM in variables that are “random-walk” or close to be random-walk variables (Bond, 2002; Roodman 2006; Baum, 2006; Roodman, 2009). Since my model specification includes macroeconomic variables that are known for the presence of random walk statistical generating mechanisms (e.g. inflation), the SGMM approach seems to be the more appropriate choice. Second, the DGMM may be subject to large finite sample biases when the instruments available are weak, while the SGMM approach generally produces more efficient and precise estimates compared to DGMM by improving precision and reducing the finite sample bias (Baltagi, 2008). Given the number of time series observations is moderately small, which is at most 5 periods in our data, the SGMM is preferred. Additionally, if an unbalanced panel is present, which is the case here, it is better to avoid DGMM estimation, which has a weakness of magnifying gaps (Roodman, 2006). Above all, to estimate the dynamic model consistently from a short and unbalanced panel, system GMM is a more reliable one. In the finance-growth literature, it is common and standard to use system GMM to estimate the link (e.g. Beck and Levine, 2004; Arcand et al. 2015).

For the special case of homoscedasticity, we can obtain a one-step GMM estimator that is asymptotically equivalent to the two-step GMM for the first-differenced estimator. In other cases, the two-step estimator is more efficient. However, according to Blundell and Bond (1998), Monte Carlo studies have shown that the efficiency gain is typically small. In addition, asymptotic standard errors for the two-step GMM estimators tend to underestimate the true dispersion of these estimators in finite samples. In finite samples, the asymptotic standard errors associated with the two-step GMM estimators can be seriously biased downwards, and thus form an unreliable guide for inference. Hence, inference based on the one-step GMM

estimators appears to be much more reliable when either non-normality or heteroskedasticity is suspected.

With this in mind, the results for the one-step system GMM estimators are reported, with standard errors that are not only asymptotically robust to heteroscedasticity but have also been found to be more reliable for finite sample inference. Relying mainly on the one-step system GMM estimates, we also include OLS estimations as a reference.

Model 2

$$\Delta y_{it} = \alpha + \beta_1 y_{it-1} + \beta_2 SIZE_{it} + \beta_3 DEPTH_{it} + \beta_4 EFF_{it} + \beta_5 Cor_{it} + \beta_6 SIZE_{it} * Cor_{it} \\ + \beta_7 DEPTH_{it} * Cor_{it} + \beta_8 EFF_{it} * Cor_{it} + \gamma' X_{it} + (\eta_i + \delta_t + \varepsilon_{it})$$

We move on to Model 2 by including the interaction terms of each bank indicator and corruption. This is the key model, given the main interest is to assess how banking development and corruption interactively related to economic growth. I will run the regression for the whole sample first and then the subsamples determined by corruption level⁶. The group denoted by LESSCORR consists of less corrupt countries whose corruption control level is above the median. The other one denoted by MORECORR is composed by more corrupt countries whose corruption control is below the median. So the countries in LESSCORR group have corruption under better control, while corruption problem is more severe for countries in MORECORR group. By running regressions on both groups and comparing the result, we can test whether the impacts of bank development and corruption on growth differ in countries with different corruption levels.

2.5 Results

Table 2.5 presents the result of Model 1 under both OLS and system GMM estimations. As argued above, I will mainly rely on the results of system GMM estimation, with the OLS results as a reference. The results of the first two columns are based on regressions with initial income and years of schooling controlled for. We will refer to it as simple conditioning information set. The last two columns add to trade openness, government expenditure and inflation as additional controls, which will be referred to as policy conditioning information set.

⁶ The motivation to carry out subsample regression is that corruption is believed to have different effects on economic growth as corruption level varies. For example, Ahlin (2005) and Ehrlich and Lui (2000) both proposed models where the impact of corruption on growth varies with corruption level.

As we can see, SIZE measure of banking system has negative signs in both specifications and is significant under system GMM estimation, indicating that improving SIZE measure of bank system is harmful to economic growth keeping other variables constant. It is in line with some of the past research, which fails to find positive link between finance and growth.

DEPTH and EFF are both significantly related to growth with expected positive and negative signs respectively, suggesting that deeper and more efficient banking system is beneficial to economic growth. However, corruption coefficient is small and not significant from 0. The Arellano-Bond autocorrelation tests for second-order correlation are not significant at the 5% level for both conditioning information sets, suggesting that we cannot reject the null that there is no second-order correlation in differences, thus no first-order serial correlation in levels⁷. The *p* value of the Hansen test is rather high, but not a perfect statistic of 1.00, which not only suggests strong validity of the instruments, but also eases the worry about instruments proliferation⁸. In addition, the number of instruments is smaller than the number of groups⁹. The weak identification test shows the *p* value of the Wald statistics, which is significant at 0.05 level. It rejects the null that the instruments are weakly related to the endogenous variables.

To see the economic significance of the growth effect of bank indicators, take Kenya for instance, whose SIZE and DEPTH are 0.221 and 0.709 during the period 2004-2009. If SIZE were exogenously raised to the sample median of 0.355, the coefficient estimates from system GMM indicate that Kenya's growth would have grown 0.2 percentage points per year, others holding constant. If its DEPTH of bank development were increased for the same period to the sample median of 0.912, the growth would have increased 0.3 percentage points per year, others holding constant.

Table 2.6 shows the results of the interaction model, the one we are more interested in. SIZE measure of banking system remains negatively related to economic growth, but it becomes insignificant under policy conditioning information set and the insignificance of interaction

⁷ Negative first-order serial correlation is expected in differences and evidence of it is uninformative. So AR(1) test results are not provided.

⁸ A perfect *p* value of 1.00 is argued as the classic sign of instrument proliferation weakening the ability of Hansen test. See Roodman (2009).

⁹ Throughout the paper, the number of instruments is smaller than the number of groups for most of the specifications. For those regressions with larger number of instruments than groups, the results should be interpreted with caution.

term indicates that the marginal growth effect of SIZE measure of bank system and corruption are independent of each other. Bank DEPTH remains significantly positive in each specification and in addition the interaction term shows significant negative coefficient consistently, suggesting that the marginal growth effect of improving bank depth decreases if corruption control is improved. In other words, bank DEPTH has a greater growth effect in a more corrupt country. One explanation is that improved corruption control may crowd out the growth effect from bank development. The control variables all show expected signs. In particular, education and government expenditure are significant, implying that more education and less government expenditure are beneficial to economic growth¹⁰.

For example, if we look at Kenya again, this time with interaction with corruption considered, improving bank DEPTH from 0.709 to median level 0.912 during the period 2004-2009 will lead to almost 1% increase in annual growth rate, significantly larger than 0.3% growth effect from Model 1. It is largely due to the fact that Kenya is very corrupt with corruption value 0.64. If Kenya improved its corruption control to the sample median level 2.88, the growth benefit from improving DEPTH would be halved with only 0.5% increase in growth per year. Bank EFF loses significance in the full sample result, and the interaction term is not significant either. As the case in Model 1, direct growth effect of corruption control is positive, small and insignificant.

The subsample results in Table 2.7 support the hypothesis that the growth effect is different in different country groups. The first four columns show the results using simple conditioning information set, and information set, and the last four columns have included additional controls which comprise policy conditioning information set. The full sample is divided into two subsample according to the corruption level. LESSCORR represents the subsample of countries with corruption control index above the medium level, where corruption is under better control. MORECORR is the subsample of the more corrupt countries, with corruption control index below medium level. Under both the simple and policy conditioning information set, the direct growth effects of SIZE, DEPTH and EFF together with the interaction terms are all strongly significant for MORECORR subsample. Notice that SIZE still holds negative signs and

¹⁰ Initial income is not a significant factor, which could be explained by the fact that convergence effect is not significant in short-run growth, given that the data is based on 5-year windows. For example, in Beck and Levine (2002), they also failed to show its significance in explaining short-run economic growth.

interaction term of SIZE is positive in both subsamples, suggesting that improvement on bank SIZE is bad to growth and the adverse effect will be alleviated by improving corruption control in both subsamples. We are interested in how the effects differ in the two subsamples by comparing the magnitude of the coefficients. We can see that both single and interaction term of SIZE are larger in absolute value in MORECORR countries. It means that the adverse effect of increasing SIZE measure of bank system is larger in the more corrupt subsample, and the alleviation of the adverse marginal effect by improving corruption control is also larger in the more corrupt subsample. Given that DEPTH is significantly positive in MORECORR subsample and insignificant in HIGH subsample, bank DEPTH is more important in more corrupt countries. The same story applies to bank efficiency, improving bank efficiency will benefit growth in more corrupt countries. Interactions terms of DEPTH and EFF with corruption are significantly negative and positive respectively in MORECORR subsample, suggesting diminishing growth effects of DEPTH and EFF as corruption control improves. In other words, the more corrupt a country is, the more important a role bank system plays in economic growth. However, in the less corrupt countries, corruption does not affect the growth effect of bank depth and efficiency.

To see the economic significance of the effects, take Botswana and Indonesia for instance. Botswana and Indonesia have similar level of bank SIZE in period 2000-2004, 16.5% and 18.7% respectively, but their corruption levels differ. Botswana is in LESSCORR group with corruption level 3 and Indonesia is in MORECORR group with corruption level 1.2. According to the subsample results, the growth effects of bank SIZE are different for the two countries. If bank SIZE were both raised to sample median 35.5%, the annual growth rate would have decreased by 0.44% and 1.81% respectively, suggesting that growth effects indeed differ significantly in countries with different corruption levels.

Table 2.5: Result of Model 1

VARIABLES	Simple		Policy	
	(1) SGMM	(2) OLS	(3) SGMM	(4) OLS
SIZE	-0.018** (0.007)	-0.001 (0.004)	-0.013* (0.007)	-0.005 (0.004)
DEPTH	0.011* (0.006)	0.007* (0.004)	0.014** (0.006)	0.008** (0.003)
EFF	-0.398*** (0.140)	-0.234*** (0.053)	-0.171* (0.090)	-0.198*** (0.059)
Corruption Control	-0.003 (0.003)	-0.003** (0.001)	-0.003 (0.003)	-0.002 (0.001)
Initial	-0.004 (0.004)	-0.002 (0.002)	-0.003 (0.004)	-0.000 (0.002)
Education	0.022** (0.010)	0.007 (0.004)	0.025*** (0.009)	0.007 (0.004)
Trade			0.002 (0.008)	0.005** (0.002)
Government			-0.021** (0.010)	-0.013*** (0.004)
Inflation			-0.015* (0.009)	-0.003* (0.002)
Constant	0.046 (0.028)	0.037*** (0.010)	-0.025 (0.033)	-0.001 (0.013)
Observations	410	410	410	410
Adj. R-squared		0.11		0.16
Number of id	110	110	110	110
Time fixed effect	Yes		Yes	
Instrumented variables	All		All	
Lags of instruments	2+		2+	
F test of joint sig.	0.00		0.00	
Weak ident.	0.01		0.01	
AR(2)	0.73		0.07	
No. of Instruments	59.00		86.00	
Hanse-J	0.20		0.46	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Growth rate of real GDP per capita

Table 2.6: Result of Model 2

VARIABLES	Simple		Policy	
	(1) SGMM	(2) OLS	(3) SGMM	(4) OLS
SIZE	-0.042* (0.025)	-0.000 (0.014)	-0.034 (0.023)	0.000 (0.014)
DEPTH	0.048*** (0.012)	0.028*** (0.009)	0.054*** (0.013)	0.023*** (0.009)
EFF	-0.264 (0.310)	-0.224 (0.164)	-0.019 (0.280)	-0.258 (0.167)
Corruption Control	0.005 (0.007)	0.003 (0.004)	0.009 (0.007)	0.002 (0.003)
SIZE*Corruption Control	0.008 (0.006)	-0.000 (0.003)	0.006 (0.005)	-0.001 (0.003)
DEPTH*Corruption Control	-0.011*** (0.003)	-0.006*** (0.002)	-0.011*** (0.003)	-0.004** (0.002)
EFF*Corruption Control	-0.010 (0.101)	-0.002 (0.047)	-0.070 (0.084)	0.025 (0.050)
Initial	-0.003 (0.004)	-0.002 (0.002)	-0.003 (0.004)	-0.000 (0.002)
Education	0.015** (0.007)	0.006 (0.004)	0.018** (0.008)	0.006 (0.004)
Trade			0.001 (0.008)	0.004** (0.002)
Government			-0.021** (0.009)	-0.012*** (0.004)
Inflation			-0.013 (0.008)	-0.003* (0.001)
Constant	0.011 (0.026)	0.019 (0.014)	-0.059 (0.036)	-0.011 (0.015)
Observations	410	410	410	410
Adj. R-squared		0.13		0.17
Number of id	110	110	110	110
Time fixed effect	Yes		Yes	
Instrumented variables	All		All	
Lags of instruments	2+		2+	
F test of joint sig.	0.00		0.00	
Weak ident.	0.00		0.00	
AR(2)	0.70		0.07	
No. of Instruments	86.00		113.00	
Hanse-J	0.65		0.90	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Growth rate of real GDP per capita

Table 2.7: Subsample result

VARIABLES	LESSCORR			MORECORR			LESSCORR			MORECORR		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	SGMM	OLS	SGMM	OLS	SGMM	OLS	SGMM	OLS	SGMM	OLS	SGMM	OLS
SIZE	-0.116** (0.047)	-0.041** (0.017)	-0.244*** (0.061)	-0.125*** (0.046)	-0.053*** (0.019)	-0.039** (0.015)	-0.240*** (0.066)	-0.110** (0.042)				
DEPTH	0.014 (0.022)	0.033** (0.015)	0.148*** (0.042)	0.079*** (0.022)	0.018 (0.014)	0.023 (0.014)	0.172*** (0.037)	0.088*** (0.020)				
EFF	-0.082 (0.442)	-0.163 (0.157)	-1.201*** (0.404)	-0.525*** (0.245)	-0.231 (0.246)	-0.126 (0.166)	-0.918** (0.344)	-0.416* (0.237)				
Corruption Control	-0.014 (0.011)	-0.001 (0.004)	0.001 (0.014)	0.005 (0.010)	-0.009* (0.005)	-0.004 (0.004)	0.006 (0.016)	0.015 (0.010)				
SIZE* Corruption Control	0.023** (0.011)	0.008* (0.004)	0.110*** (0.026)	0.061*** (0.019)	0.010*** (0.005)	0.006 (0.004)	0.110*** (0.028)	0.056*** (0.017)				
DEPTH*Corruption Control	-0.005 (0.005)	-0.007** (0.003)	-0.063*** (0.020)	-0.030*** (0.009)	-0.003 (0.003)	-0.004 (0.003)	-0.070*** (0.016)	-0.035*** (0.009)				
EFF* Corruption Control	-0.018 (0.125)	-0.009 (0.046)	0.371** (0.151)	0.123 (0.090)	0.027 (0.066)	0.009 (0.047)	0.284** (0.135)	0.089 (0.085)				
Initial	0.013 (0.009)	0.001 (0.003)	0.001 (0.004)	-0.003 (0.002)	-0.000 (0.003)	0.003 (0.002)	-0.001 (0.004)	-0.002 (0.002)				
Education	-0.012 (0.021)	-0.002 (0.006)	0.009 (0.008)	0.004 (0.005)	0.003 (0.009)	-0.002 (0.006)	0.011 (0.008)	0.007 (0.005)				

Table 2.7 (continued)

VARIABLES	LESSCORR			MORECORR			LESSCORR			MORECORR		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	SGMM	OLS	SGMM	OLS	SGMM	OLS	SGMM	OLS	SGMM	OLS	SGMM	OLS
Trade					0.008*	0.009***	-0.015*	-0.009*				
					(0.004)	(0.002)	(0.009)	(0.005)				
Government					-0.004	-0.010*	-0.022	-0.013**				
					(0.006)	(0.005)	(0.014)	(0.005)				
Inflation					-0.012	-0.002	-0.008	-0.005***				
					(0.011)	(0.001)	(0.013)	(0.001)				
Constant	0.015	0.037*	0.002	0.014	0.067**	0.010	-0.066	-0.060*				
	(0.067)	(0.020)	(0.039)	(0.028)	(0.032)	(0.024)	(0.074)	(0.032)				
Observations	217	217	193	193	217	217	193	193				
Adj. R-squared		0.08		0.31		0.19		0.36				
Number of id	55	55	55	55	55	55	55	55				
Time fixed effect	Yes		Yes		Yes		Yes					
Instrumented variables	All		All		All		All					
Lags of instruments	2		2		2		2					
F test of joint sig.	0.02		0.00		0.00		0.00					
Weak ident.	0.03		0.00		0.00		0.00					
AR(2)	0.52		0.19		0.41		0.92					
Instruments	41.00		55.00		77.00		67.00					
Hanse-J	0.76		0.71		0.96		0.81					

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Growth rate of real GDP per capita

2.6 Robustness checks

To check the robustness of the above empirical results, I have done a wide variety of sensitivity analysis. This section will show the checks on outliers, different measures of bank development, other institutional quality indicators, additional controls, recent crisis, nonlinearity, convergence effects and subsample division.

2.6.1 Outliers

I have identified outliers using “hadimvo” command in Stata 13 and run regressions above dropping the outliers. The results are shown in Table 2.8. We can see that deleting outliers barely changes the full sample or subsample results. In addition, it does not change the overall pattern that the growth effects of bank development and the extent to which corruption affects the bank-growth link are stronger in more corrupt countries, by comparing the absolute values of the coefficients in subsamples. Thus, we conclude that the main results in Table 2.6 and Table 2.7 are not driven by outliers.

2.6.2 Different measures of bank development and corruption

2.6.2.1 Total credit/GDP as measure of bank SIZE

In Section 2.3, we have explained why we use private credit/GDP as a measure of bank development. It is a direct and general measure and at the same time, we could easily compare our results with other works which also use this indicator. Despite of the dominant role of credits issued to private sector across most countries, there is still a concern about whether the credit issued to government, governments’ agencies, and especially public enterprises matters, especially for the developing countries, which are excluded from the private credit/GDP indicator. To assess the possibility that the main results are driven by the ignorance of credits issued to other sectors, we have replaced private credit/GDP by total credit/GDP.

Once we replace private credit/GDP by total credit/GDP, Table 2.9 shows that the significance of interaction term of DEPTH and corruption remains for full sample results , while the coefficient for total credit/GDP becomes insignificant and close to 0, while EFF indicator becomes significant with expected sign. So the full sample results are stronger after the change. The subsample results become slightly weaker considering the losses of significance of the interaction terms for the MORECORR group. However, the bank indicators remain

significant for the MORECORR group and contrast with the results of LESSCORR group. Therefore, the different effects in LESSCORR and MORECORR groups still hold.

Table 2.8: Robustness check for outliers

VARIABLES	FULL SAMPLE		LESSCORR		MORECORR	
	SIMPLE	POLICY	SIMPLE	POLICY	SIMPLE	POLICY
SIZE	-0.050*	-0.046**	-0.082**	-0.118***	-0.246***	-0.239***
	(0.028)	(0.021)	(0.039)	(0.025)	(0.058)	(0.063)
DEPTH	0.057***	0.060***	0.002	0.045*	0.169***	0.166***
	(0.015)	(0.018)	(0.032)	(0.024)	(0.042)	(0.037)
EFF	-0.188	-0.128	-0.285	-0.937*	-2.254***	-1.536***
	(0.442)	(0.312)	(0.473)	(0.514)	(0.645)	(0.466)
Corruption Control	0.007	0.008	-0.016	-0.014	-0.015	-0.005
	(0.008)	(0.008)	(0.011)	(0.008)	(0.020)	(0.016)
SIZE*	0.010	0.008*	0.017*	0.024***	0.108***	0.109***
	(0.007)	(0.005)	(0.010)	(0.006)	(0.025)	(0.025)
Corruption Control						
DEPTH*	-0.014***	-0.013***	-0.004	-0.012*	-0.066***	-0.067***
	(0.004)	(0.004)	(0.009)	(0.006)	(0.019)	(0.014)
Corruption Control						
EFF*	-0.070	-0.060	0.022	0.202	0.816***	0.583***
	(0.115)	(0.092)	(0.144)	(0.144)	(0.245)	(0.196)
Corruption Control						
Initial	-0.001	-0.000	0.006	0.003	-0.001	0.000
	(0.003)	(0.004)	(0.008)	(0.006)	(0.005)	(0.005)
Education	0.010	0.014	-0.006	-0.011	0.013	0.011
	(0.008)	(0.009)	(0.014)	(0.012)	(0.011)	(0.010)
Trade		0.005		0.016*		-0.013
		(0.006)		(0.008)		(0.010)
Government		-0.023**		-0.017		-0.029**
		(0.010)		(0.013)		(0.012)
Inflation		-0.017		-0.038**		-0.010
		(0.012)		(0.018)		(0.012)
Constant	0.008	-0.060	0.080	0.077	0.037	-0.068
	(0.033)	(0.042)	(0.053)	(0.047)	(0.053)	(0.079)
Observations	405	405	203	203	202	202
Number of id	110	110	50	50	60	60
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Instrumented	All	All	All	All	All	All
Lags of	2+	2+	2	2	2	2
F test of joint sig.	0.00	0.00	0.00	0.00	0.00	0.00
Weak ident.	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)	0.61	0.06	0.22	0.09	0.92	0.10
Instruments	86.00	113.00	41.00	53.00	55.00	67.00
Hanse-J	0.73	0.93	0.39	0.39	0.75	0.89

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1
 Dependent variable: Growth rate of real GDP per capita

Table 2.9: Robustness check for total credit/GDP as the SIZE measure

VARIABLES	FULL SAMPLE		LESSCORR		MORECORR	
	SIMPLE	POLICY	SIMPLE	POLICY	SIMPLE	POLICY
Total Credit/GDP	-0.000 (0.412)	-0.000 (0.411)	-0.000 (0.653)	-0.000 (0.402)	-0.001** (0.023)	-0.000 (0.509)
DEPTH	0.025* (0.057)	0.044*** (0.000)	-0.008 (0.678)	-0.042 (0.282)	0.042 (0.144)	0.070* (0.068)
EFF	-0.331*** (0.000)	-0.350*** (0.000)	-0.417 (0.418)	-1.075* (0.093)	-0.397*** (0.000)	-0.373*** (0.000)
Corruption Control	0.008 (0.196)	0.009 (0.161)	-0.012 (0.288)	-0.027* (0.083)	-0.016 (0.310)	0.005 (0.784)
Total Credit/GDP*	0.000 (0.670)	0.000 (0.492)	-0.000 (0.913)	0.000 (0.926)	0.000*** (0.003)	0.000 (0.319)
Corruption Control	-0.007** (0.029)	-0.010*** (0.001)	0.003 (0.482)	0.009 (0.294)	-0.010 (0.428)	-0.020 (0.188)
DEPTH*Corruption	Control (0.359)	Control (0.998)	Control (0.665)	Control (0.330)	Control (0.289)	Control (0.804)
EFF*Corruption	-0.047 (0.645)	0.000 (0.203)	-0.067 (0.222)	0.143 (0.074)	0.058 (0.812)	-0.021 (0.623)
Control	Initial (0.544)	Initial (0.121)	Initial (0.059)	Initial (0.133)	Initial (0.399)	Initial (0.785)
Education	Trade (0.544)	Trade (0.121)	Trade (0.059)	Trade (0.133)	Trade (0.399)	Trade (0.785)
Trade		0.001 (0.950)		0.000 (0.972)		0.006 (0.624)
Government		-0.023*** (0.007)		-0.020 (0.280)		-0.019** (0.049)
Inflation		-0.002** (0.029)		-0.002** (0.046)		-0.002 (0.598)
Constant	0.025 (0.250)	-0.035 (0.217)	0.125** (0.036)	0.099 (0.201)	0.044 (0.275)	-0.011 (0.842)
Observations	428	428	226	226	202	202
Number of id	116	116	58	58	58	58
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Instrumented variables	All	All	All	All	All	All
Lags of instruments	2	2	2	2	2	2
F test of joint sig.	0.00	0.00	0.00	0.00	0.00	0.00
Weak ident.	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)	0.78	0.53	0.74	0.34	0.78	0.97
Instruments	121.00	97.00	73.00	63.00	73.00	63.00
Hanse-J	0.52	0.24	0.86	0.28	0.88	0.61

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Growth rate of real GDP per capita

Table 2.10: Robustness check for overhead cost as the EFF measure

VARIABLES	FULL SAMPLE		LESSCORR		MORECORR	
	SIMPLE	POLICY	SIMPLE	POLICY	SIMPLE	POLICY
SIZE	-0.054** (0.013)	-0.043* (0.051)	-0.126*** (0.001)	-0.108*** (0.001)	-0.215*** (0.003)	-0.167*** (0.004)
DEPTH	0.056*** (0.001)	0.055*** (0.000)	0.033 (0.257)	0.033 (0.127)	0.150** (0.020)	0.147*** (0.001)
Overhead	-0.527** (0.012)	-0.210 (0.349)	-0.656 (0.312)	-0.533 (0.314)	-1.162** (0.032)	-0.635* (0.079)
Corruption Control	0.005 (0.318)	0.009* (0.098)	-0.015 (0.174)	-0.014 (0.107)	0.008 (0.569)	0.019 (0.196)
SIZE*	0.009 (0.101)	0.007 (0.183)	0.025*** (0.003)	0.020*** (0.005)	0.092*** (0.002)	0.076*** (0.002)
Corruption Control						
DEPTH*	-0.011*** (0.002)	-0.011*** (0.001)	-0.009 (0.115)	-0.007* (0.082)	-0.057** (0.038)	-0.056*** (0.005)
Corruption Control						
Overhead*	-0.011 (0.884)	-0.065 (0.401)	0.075 (0.589)	0.090 (0.460)	0.310 (0.181)	0.131 (0.443)
Corruption Control						
Initial	-0.004 (0.235)	-0.004 (0.327)	0.010 (0.298)	0.009 (0.161)	-0.001 (0.808)	-0.004 (0.284)
Education	0.019*** (0.009)	0.022*** (0.009)	-0.013 (0.546)	-0.004 (0.846)	0.010 (0.331)	0.014 (0.133)
Trade		-0.000 (0.996)		0.011 (0.241)		-0.014 (0.115)
Government		-0.021** (0.025)		-0.026* (0.062)		-0.015 (0.210)
Inflation		-0.011 (0.189)		-0.006 (0.552)		-0.011 (0.241)
Constant	0.019 (0.423)	-0.052 (0.147)	0.047 (0.465)	-0.010 (0.857)	-0.003 (0.910)	-0.060 (0.195)
Observations	409	409	205	205	204	204
Number of id	110	110	50	50	60	60
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Instrumented variables	All	All	All	All	All	All
Lags of instruments	2	2	2	2	2	2
F test of joint sig.	0.00	0.00	0.00	0.00	0.00	0.00
Weak ident.	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)	0.98	0.06	0.44	0.98	0.92	0.09
Instruments	77.00	101.00	41.00	53.00	55.00	67.00
Hanse-J	0.49	0.62	0.34	0.24	0.45	0.93

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent variable: Growth rate of real GDP per capita

2.6.2.2 Overhead cost as measure of bank EFF

In the previous sections, the measure of bank efficiency is net interest margin, which is an overall measure of how banks work efficiently. The inefficiency may come from many factors, like transaction cost and other payment services. In this section, we check the robustness of the results by replacing net interest margin by another efficiency measure of banks, overhead cost. It is a more specific and direct measure of banks' operating efficiency, which is defined as the accounting value of a bank's overhead costs as a share of its total assets. Like net interest margin, it is constructed from raw bank-level data from the BankScope database and is unweighted average across all banks of a country for a given year. The results are shown in Table 2.10. There is no significant change in the results.

2.6.2.3 Different measure of Corruption Control

Table 2.11 shows the results of Model 1 and Model 2 when corruption level is measured by Control of Corruption Index from The Worldwide Governance Indicators (WGI) project of the World Bank. The results confirm that corruption control has no direct impact on growth. It works mainly through the bank-growth link. In addition, bank SIZE remains negatively related to growth rate, and bank DEPTH and its interaction with corruption are significant. The results suggest that the original results are robust to corruption measurement.

2.6.3 Other institutional quality indicators

From Table 2.12, corruption is significantly and highly correlated with other institutional quality indicators, except with government stability. It suggests that corruption index may to some extent contain information of other aspects of institutional quality. So we need to assess the possibility that the above results are driven by other institutional qualities instead of corruption, given the strong correlation between most of the other institutional quality indicators and corruption. So I run the same regressions just replacing corruption index by other institutional quality indicators one at a time, to see if the interaction effect and subsample results hold. If the main results still hold for other institutional quality indicators, we need to do further analysis by including both corruption and one of the significant institutional quality indicators in the regression to check if it will drive away the significance of

corruption coefficients and at the same time the significance of the other institutional quality indicator remains¹¹.

Table 2.11: Robustness check for Corruption Control from WGI

VARIABLES	Model 1		Model 2	
	SIMPLE	POLICY	SIMPLE	POLICY
SIZE	-0.024*** (0.009)	-0.013* (0.008)	-0.004 (0.010)	-0.002 (0.010)
DEPTH	0.008 (0.006)	0.013** (0.006)	0.014* (0.008)	0.023*** (0.008)
EFF	-0.387*** (0.132)	-0.129 (0.090)	-0.122 (0.125)	0.028 (0.096)
Corruption Control	-0.002 (0.007)	0.003 (0.006)	0.012 (0.009)	0.019** (0.009)
SIZE* Corruption Control			-0.012* (0.006)	-0.010* (0.006)
DEPTH* Corruption Control			-0.005 (0.004)	-0.009* (0.005)
EFF* Corruption Control			0.117 (0.122)	0.076 (0.100)
Initial	-0.000 (0.006)	-0.005 (0.005)	-0.004 (0.004)	-0.006 (0.004)
Education	0.020** (0.010)	0.026*** (0.009)	0.014 (0.008)	0.016* (0.009)
Trade		0.002 (0.008)		0.004 (0.006)
Government		-0.025*** (0.009)		-0.022** (0.009)
Inflation		-0.016* (0.009)		-0.014* (0.008)
Constant	0.007 (0.041)	-0.029 (0.036)	0.023 (0.032)	-0.025 (0.030)
Observations	410	410	410	410
Number of id	110	110	110	110
Time fixed effect	Yes	Yes	Yes	Yes
Instrumented variables	All	All	All	All
Lags of instruments	2	2	2	2
F test of joint sig.	0.00	0.00	0.00	0.00
Weak ident.	0.00	0.00	0.00	0.00
AR(2)	0.59	0.07	0.64	0.09
Instruments	58.00	85.00	85.00	100.00
Hanse-J	0.07	0.33	0.77	0.79

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Table 2.13 shows the full sample and subsample results for each institutional quality indicator¹². It is unlikely that the main results of corruption are driven by Government Stability

¹¹ Otherwise we are not able to reject the hypothesis that the main results reveal a robust and true link between bank indicators, corruption and growth instead of driving by other institutional quality indicators, considering the high correlations between corruption and other institutional quality indicators may make multicollinearity a potential problem when we include two institutional quality indicators in the regression.

and Law and Order, since the results for these two indicators are insignificant for both full sample and subsample results. As to Democratic Accountability and Bureaucracy Quality, the full sample results are consistent with that of Corruption, although the subsample results are not. So in the next step we just need to do the “horserace” regressions by including the two institutional quality indicators one at a time with Corruption and run the full sample regression, which is shown in Table 2.14. We can see that the significance of DEPTH and its interaction with Corruption remains. Among the interactions of bank indicators with the other institutional indicators, interactions of SIZE are both significant for Democratic Accountability and Bureaucracy Quality, meaning that beyond the interaction effect with Corruption, bank SIZE also interactively works through Democratic Accountability and Bureaucracy Quality. In a word, although we find evidence here that Democratic Accountability and Bureaucracy Quality as institutional quality indicators also plays a significant role in the bank-growth link, we fail to find evidence supporting that the original results with corruption are driven by them despite of high correlations between corruption and Democratic Accountability and Bureaucracy Quality.

Table 2.12: Correlation of various institutional quality indicators

	CORRUPTION	GOVERNMENT STABILITY	LAW AND ORDER	DEMOCRATIC ACCOUNTABILITY	BUREAUCRACY QUALITY
CORRUPTION	1				
GOVERNMENT STABILITY	-0.03	1			
LAW AND ORDER	0.71***	0.22***	1		
DEMOCRATIC ACCOUNTABILITY	0.56***	-0.07	0.45***	1	
BUREAUCRACY QUALITY	0.74***	0.04	0.70***	0.65***	1

*** p<0.01, ** p<0.05, * p<0.1

¹² The full samples are divided into subsample according to individual institutional quality indicators. For example, the HIGH group for Government Stability indicator includes the countries with Government Stability above the median value across all the countries.

Table 2.13: Robustness check for replacing corruption by other institutional quality(IQ) indicators

	GOVERNMENT STABILITY			LAW AND ORDER			DEMOCRATIC ACCOUNTABILITY			BUREAUCRACY QUALITY		
	FULL	LESSCORR	MORECORR	FULL	LESSCO	MORECO	FULL	LESSCOR	MORECO	FULL	LESSC	MORECOR
			R		RR	RR		R	RR		ORR	R
SIZE	0.002 (0.950)	-0.028 (0.537)	0.079 (0.557)	0.020 (0.448)	-0.047 (0.366)	-0.024 (0.722)	0.030 (0.257)	-0.025 (0.421)	-0.025 (0.421)	0.019 (0.509)	-0.028 (0.488)	0.009 (0.887)
DEPTH	0.035 (0.298)	-0.026 (0.492)	0.232 (0.123)	0.022 (0.199)	0.018 (0.655)	0.037 (0.462)	0.069*** (0.003)	0.053 (0.140)	0.053 (0.140)	0.041** (0.043)	-0.000 (0.995)	-0.011 (0.799)
EFF	0.369 (0.605)	-0.744 (0.409)	-0.579 (0.723)	0.078 (0.743)	0.069 (0.893)	-0.684** (0.045)	0.038 (0.899)	-0.337 (0.499)	-0.337 (0.499)	-0.057 (0.828)	-0.497 (0.140)	-0.208 (0.595)
OTHER IQ	0.010* (0.058)	-0.002 (0.816)	0.018 (0.283)	0.014*** (0.006)	0.007 (0.646)	-0.010 (0.324)	0.019*** (0.001)	0.006 (0.589)	0.006 (0.589)	0.017** (0.046)	-0.006 (0.781)	-0.011 (0.653)
SIZE* OTHER IQ	-0.002 (0.636)	-0.000 (0.975)	-0.010 (0.494)	-0.007 (0.183)	0.004 (0.670)	0.007 (0.640)	-0.009* (0.074)	0.000 (0.952)	0.000 (0.952)	-0.008 (0.315)	0.004 (0.739)	-0.011 (0.668)
DEPTH* OTHER IQ	-0.003 (0.453)	0.004 (0.412)	-0.025 (0.145)	-0.003 (0.422)	-0.003 (0.677)	-0.004 (0.760)	-0.012*** (0.006)	-0.008 (0.192)	-0.008 (0.192)	-0.011* (0.054)	-0.000 (0.993)	0.023 (0.292)
EFF* OTHER IQ	-0.058 (0.493)	0.074 (0.517)	0.030 (0.872)	-0.074 (0.259)	-0.076 (0.551)	0.169 (0.175)	-0.040 (0.517)	0.054 (0.536)	0.054 (0.536)	-0.003 (0.982)	0.191 (0.193)	0.081 (0.710)
Initial	-0.004 (0.240)	0.008** (0.039)	-0.001 (0.915)	-0.004 (0.167)	0.005 (0.413)	-0.002 (0.767)	-0.002 (0.473)	0.003 (0.611)	0.003 (0.611)	-0.005 (0.155)	0.002 (0.825)	-0.008 (0.322)
Education	0.030*** (0.002)	-0.000 (0.980)	0.019 (0.217)	0.014* (0.071)	-0.003 (0.875)	0.013 (0.308)	0.007 (0.382)	0.015 (0.474)	0.015 (0.474)	0.016* (0.066)	0.017 (0.366)	0.015 (0.205)
Trade	0.004 (0.322)	-0.004 (0.717)	0.002 (0.850)	-0.001 (0.827)	-0.007 (0.691)	-0.002 (0.798)	0.006 (0.326)	-0.001 (0.960)	-0.001 (0.960)	0.004 (0.452)	-0.002 (0.834)	-0.000 (0.992)
Government	-0.022*** (0.008)	-0.021 (0.217)	-0.011 (0.589)	-0.021*** (0.007)	-0.020 (0.156)	0.003 (0.841)	-0.005 (0.559)	-0.024 (0.118)	-0.024 (0.118)	-0.007 (0.308)	-0.013 (0.372)	0.002 (0.925)
Inflation	-0.013* (0.092)	-0.015 (0.301)	-0.034 (0.228)	-0.011 (0.132)	-0.021 (0.235)	-0.049 (0.168)	-0.013* (0.090)	-0.016 (0.268)	-0.016 (0.268)	-0.014* (0.078)	-0.020 (0.214)	-0.045 (0.136)
Constant	-0.124** (0.014)	-0.053 (0.581)	-0.182 (0.183)	-0.065** (0.038)	-0.063 (0.436)	0.042 (0.532)	-0.067* (0.070)	-0.098 (0.171)	-0.098 (0.171)	-0.022 (0.419)	-0.025 (0.666)	0.063 (0.451)

Table 2.13 (continued)

	GOVERNMENT STABILITY			LAW AND ORDER			DEMOCRATIC ACCOUNTABILITY			BUREAUCRACY QUALITY		
	FULL	LESSCORR	MORECOR	FULL	LESSCO	MORECO	FULL	LESSCOR	MORECO	FULL	LESSC	MORECOR
			R		RR	RR		R	RR		ORR	R
Observations	409	205	204	409	205	204	409	205	205	409	205	204
Number of id	110	50	60	110	50	60	110	50	50	110	50	60
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Instrumented variables	All	All	All	All	All	All	All	All	All	All	All	All
Lags of instruments	2	2	2	2	2	2	2	2	2	2	2	2
F test of joint sig.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak ident.	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)	0.08	0.81	0.17	0.10	0.44	0.32	0.06	0.54	0.54	0.07	0.44	0.21
Instruments	113.00	53.00	48.00	113.00	53.00	48.00	113.00	53.00	53.00	113.00	53.00	48.00
Hanse-J	0.95	0.72	0.45	0.77	0.46	0.31	0.92	0.58	0.58	0.92	0.46	0.29

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Growth rate of real GDP per capita

Table 2.14: Robustness check for including other institutional quality (IQ) indicators (The “Horseshoe” regression)

VARIABLES	(1) DEMOCRATIC ACCOUNTABILITY	(2) BUREAUCRACY QUALITY
SIZE	0.014 (0.587)	-0.014 (0.582)
DEPTH	0.057*** (0.007)	0.047*** (0.004)
EFF	-0.519 (0.104)	-0.278 (0.341)
Corruption Control	-0.002 (0.776)	-0.005 (0.530)
OTHER IQ	0.014* (0.060)	0.019* (0.089)
SIZE* Corruption Control	0.015** (0.016)	0.021*** (0.003)
DEPTH* Corruption Control	-0.009** (0.024)	-0.014** (0.013)
EFF* Corruption Control	0.098 (0.245)	0.079 (0.347)
SIZE* OTHER IQ	-0.016*** (0.003)	-0.024** (0.016)
DEPTH* OTHER IQ	-0.003 (0.619)	0.004 (0.645)
EFF* OTHER IQ	0.006 -0.016***	-0.065 (0.553)
Initial	-0.004 (0.234)	-0.005 (0.178)
Education	0.005 (0.490)	0.006 (0.429)
Constant	-0.011 (0.710)	0.021 (0.314)
Observations	409	409
Number of id	110	110
Time fixed effect	Yes	Yes
Instrumented variables	All	All
Lags of instruments	2	2
F test of joint sig.	0.00	0.00
Weak ident.	0.00	0.00
AR(2)	0.95	0.74
Instruments	109.00	109.00
Hansen-J	0.78	0.82

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent variable: Growth rate of real GDP per capita

2.6.4 Additional controls

As mentioned before, the control variables are in line with Levine and Renelt (1992) and Beck and Levine (2004). Although system GMM estimation is known for its robustness to time-invariant omitted variable bias, there is still a concern about the problem of the omitted variables under system GMM estimation if there is persistence in those variables and they are correlated with the lags, given that those variables are instrumented with their lags. So here to check the robustness of the results to the selection of controls, we include another two variables, population growth and investment rate, as both are persistent and are argued as important determinants of growth in empirical literature. They are added to the regression one at a time based on the policy conditioning information set.

From Table 2.15, after adding the two control variables, bank DEPTH and its interaction terms stays significant in the full sample result, and the contrasting subsample results also hold. As to the coefficients of the control variables, we can see that population growth enters marginally significant in the full sample result meaning that it is negatively related to growth. However, it is insignificant in subsample results. Investment as percentage of GDP enters strongly significant in both full sample and subsample results, confirming that investment is one of the most important determinants in empirical growth literature.

2.6.5 Recent crisis

Some may concern that the negative relationship between bank SIZE and growth is driven by the fact that I have included the period of the recent global financial crisis, when there was credit boom and at the same time the global economy was shrinking. To ease the concern, we have dropped the crisis period. So the new period is 1985-2007. Table 2.16 shows that there is no significant difference of the results after dropping the period of recent financial crisis. In particular, we observe that bank SIZE is negatively related to growth in full sample and both subsamples. Bank DEPTH and the interaction term play significant role in full sample. In addition, all three bank indicators as well as the interaction terms are very significant for the more corrupt countries, contrasting with the case in less corrupt group.

Table 2.15: Robustness check by adding other control variables

VARIABLES	Population Growth			Investment/GDP		
	Full	LESSCORR	MORECORR	Full	LESSCORR	MORECORR
SIZE	-0.034 (0.112)	-0.095*** (0.005)	-0.248*** (0.000)	-0.025 (0.021)	-0.072*** (0.023)	-0.191*** (0.067)
DEPTH	0.044*** (0.000)	0.028 (0.202)	0.149*** (0.001)	0.036*** (0.012)	0.012 (0.013)	0.163*** (0.041)
EFF	-0.162 (0.571)	0.005 (0.989)	-1.084*** (0.001)	-0.058 (0.267)	-0.055 (0.230)	-0.684* (0.365)
Corruption Control	0.003 (0.697)	-0.009 (0.401)	-0.014 (0.356)	0.006 (0.005)	-0.011* (0.007)	0.012 (0.016)
SIZE*	0.006 (0.269)	0.017** (0.011)	0.110*** (0.000)	0.003 (0.004)	0.014** (0.005)	0.085*** (0.027)
Corruption Control						
DEPTH*	-0.008*** (0.001)	-0.007 (0.138)	-0.060*** (0.003)	-0.008*** (0.003)	-0.004 (0.003)	-0.065*** (0.017)
Corruption Control						
EFF*	-0.028 (0.747)	0.021 (0.831)	0.374*** (0.003)	-0.035 (0.084)	0.075 (0.083)	0.224* (0.131)
Corruption Control						
Initial	-0.001 (0.708)	0.011 (0.122)	0.001 (0.850)	-0.002 (0.004)	0.008 (0.005)	-0.002 (0.005)
Trade	-0.000 (0.992)	0.019 (0.167)	-0.008 (0.415)	-0.001 (0.006)	0.011 (0.008)	-0.014* (0.008)
Government	-0.022** (0.030)	-0.027 (0.133)	-0.016 (0.278)	-0.004 (0.008)	-0.010 (0.007)	-0.014 (0.013)
Inflation	-0.014* (0.088)	-0.009 (0.380)	-0.014 (0.238)	-0.012 (0.007)	-0.007 (0.009)	-0.009 (0.010)
Education	0.011 (0.226)	-0.007 (0.799)	-0.002 (0.869)	0.006 (0.006)	0.011 (0.014)	-0.001 (0.007)
Population Growth	-0.487* (0.055)	-0.010 (0.977)	-0.457 (0.204)			
Investment				0.051*** (0.009)	0.040*** (0.014)	0.035*** (0.011)
Constant	-0.029 (0.418)	-0.053 (0.423)	0.013 (0.838)	0.073* (0.041)	0.026 (0.041)	0.013 (0.062)
Observations	410	205	205	406	205	201
Number of id	110	50	60	109	50	59
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Instrumented variables	All	All	All	All	All	All
Lags of instruments	2	2	2	2	2	2
F test of joint sig.	0.00	0.00	0.00	0.00	0.00	0.00
Weak ident.	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)	0.05	0.93	0.14	0.04	0.92	0.42
Instruments	109.00	57.00	71.00	122.00	57.00	71.00
Hanse-J	0.68	0.50	0.96	0.98	0.69	0.96

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1
 Dependent variable: Growth rate of real GDP per capita

Table 2.16: Robustness check for different time period 1985-2007: excluding recent crisis

VARIABLES	(1) Full	(2) LESSCORR	(3) MORECORR
SIZE	-0.048** (0.049)	-0.053** (0.017)	-0.266*** (0.003)
DEPTH	0.046*** (0.001)	0.018 (0.208)	0.162*** (0.000)
EFF	-0.230 (0.441)	-0.265 (0.404)	-1.339*** (0.004)
Corruption Control	0.003 (0.742)	-0.009 (0.130)	-0.014 (0.419)
SIZE* Corruption Control	0.009 (0.114)	0.010* (0.067)	0.117*** (0.001)
DEPTH* Corruption Control	-0.009*** (0.001)	-0.003 (0.276)	-0.064*** (0.002)
EFF* Corruption Control	-0.016 (0.861)	0.033 (0.645)	0.463*** (0.009)
Initial	-0.002 (0.595)	0.001 (0.744)	0.000 (0.990)
Trade	-0.001 (0.861)	0.006 (0.155)	-0.010 (0.294)
Government	-0.022** (0.023)	-0.008 (0.402)	-0.021 (0.158)
Inflation	-0.011 (0.161)	-0.008 (0.480)	-0.010 (0.356)
Education	0.020** (0.025)	0.014 (0.236)	0.004 (0.671)
Constant	-0.044 (0.274)	0.020 (0.636)	-0.014 (0.838)
Observations	410	205	205
Number of id	110	50	60
Time fixed effect	Yes	Yes	Yes
Instrumented variables	All	All	All
Lags of instruments	2	2	2
F test of joint sig.	0.00	0.01	0.00
Weak ident.	0.00	0.00	0.00
AR(2)	0.04	0.67	0.24
Instruments	101.00	77.00	67.00
Hanse-J	0.80	0.97	0.91

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Growth rate of real GDP per capita

2.6.6 Nonlinear effects

Recent literature has provided evidence suggesting that the effect of financial development on growth exhibits diminishing returns¹³. In this case, given the high correlation between corruption and bank development (see Table 2.2 and Table 2.4), the significance of the interaction terms may be simply driven by the diminishing effect of banking development on growth. To assess this possibility, squared banking indicators are added to original model. If interaction term loses significance and squared banking terms gain significance at the same time, we conclude that the interaction effect is simply driven by the diminishing growth effect of bank development on growth and the high correlation between banking development and corruption. Otherwise, we cannot reject the original results.

Colum 1-3 of Table 2.17 shows the results. The squared terms of bank development are mostly insignificant and do not drive away the significant results of interaction terms of the full sample and MORECORR countries. Thus the results are quite robust to the nonlinearity of banking development on growth.

Since recent studies also suggest that corruption may also have nonlinear effect on growth¹⁴, we have repeated the above robustness check by adding squared corruption term instead of squared banking development terms to the original models. Based on the similar argument, we can check whether the interaction effect is driven by the simple correlation between corruption and banking development or not.

Colum 4-6 of Table 2.17 presents the results. For the full sample, bank DEPTH and the interaction term remain significant, while quadratic corruption term is insignificant. For MORECORR sample, all the bank indicators along with their interaction terms are significant, while in LESSCORR sample, most of them are insignificant, which is consistent with the original results.

Overall, the evidence indicates that the results are not driven by nonlinear growth effect of corruption or banking development.

¹³ See Rioja and Valev (2004), Levine et al. (2000) and De Gregorio and Guidotti (1995).

¹⁴ See Ehrlich and Lui (2000) and Ahlin (2005).

Table 2.17: Robustness check for nonlinearity

VARIABLES	(1) FULL	(2) LESSCORR	(3) MORECORR	(4) FULL	(5) LESSCORR	(6) MORECORR
SIZE	-0.006 (0.823)	-0.055* (0.081)	-0.105 (0.143)	-0.030 (0.132)	-0.055** (0.043)	-0.137* (0.060)
DEPTH	0.032** (0.018)	0.015 (0.390)	0.102** (0.050)	0.052*** (0.000)	0.005 (0.787)	0.155*** (0.010)
EFF	-0.130 (0.739)	0.184 (0.740)	0.258 (0.646)	-0.118 (0.678)	-0.165 (0.580)	-0.109 (0.808)
Corruption Control	0.004 (0.551)	-0.012 (0.152)	0.022 (0.241)	0.003 (0.796)	-0.013 (0.462)	0.051 (0.221)
SIZE* Corruption Control	0.009 (0.158)	0.015* (0.077)	0.069** (0.048)	0.005 (0.312)	0.008 (0.217)	0.061** (0.042)
DEPTH* Corruption Control	-0.011*** (0.000)	-0.003 (0.631)	-0.044** (0.042)	-0.010*** (0.000)	-0.001 (0.847)	-0.064** (0.022)
EFF* Corruption Control	-0.006 (0.953)	0.046 (0.664)	-0.003 (0.987)	-0.018 (0.835)	0.023 (0.822)	-0.070 (0.685)
SIZE^2	-0.020* (0.076)	-0.012 (0.197)	-0.033 (0.378)			
DEPTH^2	0.007 (0.120)	-0.003 (0.651)	0.003 (0.838)			
EFF^2	-0.208 (0.862)	-2.045 (0.436)	-2.777 (0.444)			
Corruption Control ^2				0.001 (0.643)	0.000 (0.911)	-0.002 (0.795)
Initial	-0.002 (0.540)	0.008 (0.109)	-0.001 (0.821)	-0.002 (0.569)	0.004 (0.302)	-0.002 (0.594)
Education	0.013* (0.098)	-0.009 (0.583)	0.016 (0.134)	0.017** (0.045)	-0.001 (0.921)	0.016 (0.150)
Trade	0.000 (0.958)	0.016 (0.176)	-0.003 (0.749)	0.002 (0.813)	0.014 (0.112)	-0.007 (0.489)
Government	-0.017* (0.074)	-0.001 (0.894)	-0.014 (0.490)	-0.019** (0.046)	-0.006 (0.597)	-0.023 (0.208)
Inflation	-0.011 (0.152)	-0.012 (0.252)	-0.026 (0.376)	-0.013 (0.124)	-0.013 (0.260)	-0.030 (0.298)
Constant	-0.033 (0.375)	0.022 (0.680)	-0.099 (0.281)	-0.049 (0.221)	0.056 (0.195)	-0.138 (0.130)
Observations	410	217	193	410	217	193
Number of id	110	55	55	110	55	55
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Instrumented variables	All	All	All	All	All	All
Lags of instruments	2	2	2	2	2	2
F test of joint sig.	0.00	0.00	0.00	0.00	0.00	0.00
Weak ident.	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)	0.09	0.26	0.34	0.07	0.39	0.24
Instruments	95.00	65.00	57.00	109.00	57.00	51.00
Hanse-J	0.52	0.92	0.45	0.67	0.38	0.30

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Growth rate of real GDP per capita

2.6.7 Subsamples divided by income level

The previous subsample results are based on division of full sample according to the corruption level. Considering the fact that rich countries are more likely to be less corrupt, we want to check if the strong contrasting results from more and less corrupt country groups still hold when we divide the full sample into two groups according to the World Bank country classification of income level. The countries classified as High Income and Upper Middle

Income are denoted by RICH, while the countries classified as Lower Middle Income and Low Income are denoted by POOR. From Table 2.18, we could see that the results for the POOR countries are consistent with the full sample result, while the RICH subsample result is quite weak. Therefore, we could conclude that subsample result based on corruption level shown in Table 2.8 is not driven by the correlation between corruption and income level.

Table 2.18: Robustness check for subsample results: divided by income level

VARIABLES	(1) RICH	(2) POOR
SIZE	-0.034 (0.349)	-0.069 (0.458)
DEPTH	0.017 (0.368)	0.176** (0.011)
EFF	-0.282 (0.293)	0.359 (0.522)
Corruption Control	-0.004 (0.508)	0.050** (0.025)
SIZE* Corruption Control	0.000 (0.992)	0.041 (0.304)
DEPTH* Corruption Control	-0.001 (0.847)	-0.064* (0.065)
EFF* Corruption Control	0.060 (0.519)	-0.172 (0.399)
Initial	0.007 (0.423)	-0.009 (0.527)
Education	0.024 (0.175)	0.012 (0.432)
Trade	0.006 (0.612)	-0.021 (0.223)
Government	-0.022 (0.141)	-0.014 (0.583)
Inflation	-0.019** (0.041)	-0.068 (0.579)
Constant	-0.098 (0.171)	-0.122 (0.414)
Observations	263	147
Number of id	67	43
Time fixed effect	Yes	Yes
Instrumented variables	All	All
Lags of instruments	2	2
F test of joint sig.	0.01	0.00
Weak ident.	0.01	0.00
AR(2)	0.10	0.71
Instruments	53.00	44.00
Hanse-J	0.30	0.92

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1
 Dependent variable: Growth rate of real GDP per capita

2.7 Conclusion

The main findings are as follows. First, when assessing the finance-growth link, only looking at the size indicator, which is the common strategy in most finance-growth literature, is a potential problem. It overstressed the importance of one aspect of banking development by neglecting others, which empirically proved to be at least as important as size measure. Our empirical findings also show that SIZE measure of banking system is found negatively related to economic growth in full sample and subsample results, while bank depth is positively related to growth. Bank efficiency is also good to economic growth, but its effect is not significant in full sample. Thus, this paper is a contribution to the finance-growth literature, in the sense that it looks beyond the traditional measure. However, we still need more sophisticated and comprehensive measure of financial development, which ideally should be the ones that directly cover all functions of financial system. Although our indicators takes into account functions like mobilizing savings, some functions are still ignored, such as monitoring firms and exerting corporate control, and facilitating risk amelioration.

Second, corruption matters in the bank-growth link. Bank development plays a more important role in more corrupt countries. More specifically, within more corrupt countries, the positive effects of increasing bank DEPTH and EFFICIENCY will diminish if corruption control is improved. In both full and subsample results, bank SIZE is found to be negatively related to growth. But the adverse effect is alleviated by improvement of corruption control.

Third, the mixed evidence on the growth effect of corruption adds to the inconsistency in the corruption-growth evidence. As a complex concept, corruption takes many forms, and there is no reason to believe that all types of corruption are harmful for growth in the same way. As our model predicts, corruption might affect growth indirectly through bank system, rather than directly. Existing data, however, are by and large too coarse to examine different types of corruption in a cross-section of countries. In addition, one limitation of the work is that the indicator of corruption is subjective, which is also common to other works involving institutional measures.

Appendix to Chapter 2

Table 2.19: Data Source

Indicators	Source	Period	Frequency
GDP per capita (constant 2000 US\$)	World Development Indicators	1960-2010	Annual
GDP per capita growth (annual %)	World Development Indicators	1961-2010	Annual
Trade (% of GDP)	World Development Indicators	1960-2010	Annual
General government final consumption expenditure (% of GDP)	World Development Indicators	1960-2010	Annual
Inflation, GDP deflator (annual %)	World Development Indicators	1961-2010	Annual
Average years of total schooling, 25+, total	Barro-Lee Educational Attainment Dataset	1960-2010	5-year
Government stability	International Country Risk Guide: Researcher's Dataset	1984-2011	Annual
Corruption Control	International Country Risk Guide: Researcher's Dataset	1984-2011	Annual
Law and order	International Country Risk Guide: Researcher's Dataset	1984-2011	Annual
Democratic accountability	International Country Risk Guide: Researcher's Dataset	1984-2011	Annual
Bureaucracy quality	International Country Risk Guide: Researcher's Dataset	1984-2011	Annual
Private credit	Financial Development and Structure Database	1960-2009	Annual
Private credit to bank deposits	Financial Development and Structure Database	1960-2009	Annual
Net interest margin	Financial Development and Structure Database	1987-2009	Annual
Overhead cost	Financial Development and Structure Database	1987-2009	Annual

Table 2.20: List of Countries

Less Corrupt Countries (HIGH)		More Corrupt Countries (LOW)	
Argentina	Korea, Rep.	Albania	Moldova
Australia	Luxembourg	Algeria	Morocco
Austria	Malawi	Armenia	Niger
Belgium	Malaysia	Bahrain	Pakistan
Botswana	Malta	Bangladesh	Panama
Brazil	Mongolia	Bolivia	Papua New Guinea
Bulgaria	Mozambique	Cameroon	Paraguay
Canada	Netherlands	Colombia	Peru
Chile	New Zealand	Congo, Rep.	Philippines
Costa Rica	Norway	Croatia	Qatar
Cyprus	Poland	Côte d'Ivoire	Russian Federation
Czech Republic	Portugal	Egypt, Arab Rep.	Saudi Arabia
Denmark	Romania	El Salvador	Senegal
Dominican Republic	Singapore	Ghana	Sierra Leone
Ecuador	Slovak Republic	Guatemala	Sudan
Estonia	Slovenia	Guyana	Syrian Arab Republic
Finland	South Africa	Haiti	Thailand
France	Spain	Honduras	Togo
Gambia, The	Sri Lanka	India	Trinidad and Tobago
Germany	Sweden	Indonesia	Tunisia
Greece	Switzerland	Jamaica	Turkey
Hong Kong, China	Tanzania	Kazakhstan	Uganda
Hungary	United Kingdom	Kenya	Venezuela, RB
Iceland	United States	Kuwait	Vietnam
Iran, Islamic Rep.	Uruguay	Latvia	Yemen, Rep.
Ireland		Libya	Zambia
Israel		Lithuania	
Italy		Mali	
Japan		Mexico	

Chapter 3 Inequality and Development Revisited: Insights from New Instruments

3.1 Introduction

As Arthur M. Okun (1975) concluded his book mentioning, "the conflict between equality and economic efficiency is inescapable", discussions about inequality never end and are inescapable, since it is not only an economic but also political and social justice concern. While the focus of his book is on tradeoff between equality and efficiency, as is well known to all that the debates on inequality are far beyond this perspective. This paper attempts to contribute to another old but not yet conclusive debate on inequality, which is the impact of income inequality on economic development. Is there a positive impact or negative, or no effect at all?

One of the challenges in cross-country analysis is to use valid instruments to assess the causal link from inequality to economic development. Inspired by a hypothesis of Putterman and Weil (2010), this paper attempts to reassess the impact of inequality on economic development based on two instruments. They were first constructed in Putterman and Weil (2010). They are within-country standard deviations of historical agriculture and states development accounting for population movement and composition in each country, which capture within-country variation of early development levels of current population. They are denoted by *st_statehist* and *st_agyears*. They have a strong predictive power on current inequality across countries, suggesting a nature candidate of instruments for current income inequality. A country made up of people with little or less difference of early development, would tend to be more equal, since their similar levels of early development will determine their similar levels of productivity and income. A country made up of people with huge difference in early development would lead to greater inequality, since the large heterogeneity would lead to divergence of productivity and income, and the pattern is persistent and not easy to erase. More importantly, the paper argues that exclusion restriction applies and they are valid instruments to assess the link between income inequality and economic development. The intuition behind is that once migration took place, the heterogeneity will immediately play an important role in determining the divergence of productivity and thus income of different groups of people. Therefore the income inequality pattern of the country will be formed immediately. Considering that it may take much longer time to make other competing

channels to work, such as through institution, it is more likely that it would first and directly work on inequality since its impact on distribution of endowments or income is more prompt. After its impact on income inequality, inequality itself may gradually affect other factors, like institution. In addition, given that the mean rather than the standard deviation of early development has a direct impact on current development, the instruments may not have a direct impact on current development, except through inequality.

This paper confirms with cross-country data that heterogeneity in early development predicts current income inequality and inequality predicts development. The main finding is the casual link from inequality to development to be significantly positive across the whole sample countries. This is in line with “good inequality” hypothesis in the literature that finds positive effect of inequality on economic development (see for example Forbes, 2000; Li and Zou, 1998; Lundberg and Squire, 2003; Casey and Owen 2014). Subsample results are consistent with the hypothesis in Galor and Moav (2004) that inequality stimulates economic development in the early stages of development, when physical capital accumulation is the primary source of growth. In addition, I have tested various hypotheses of the channels through which inequality may impact income. The evidence supports the redistributive median-voter channel by confirming the negative link between inequality and income in democratic countries. The next section reviews previous research on the topic. Section 3.3 discusses the methodology and empirical results, including the robustness of the results. Section 3.4 investigates the mechanisms, and section 3.5 concludes.

3.2 Previous research

In spite of the large literature attempting to assess the impact of income inequality on economic development, the empirical literature has failed to reach a consensus on the overall effect of inequality on economic performance¹⁵. Voitchovsky (2009) provides a comprehensive survey. Some works support “bad inequality” hypothesis, especially from the early cross-sectional OLS estimations. Alesina and Rodrick (1994), Alesina and Perotti (1996), Persson and Tabellini (1994) and Perotti (1996) are among the early cross-country growth regressions that identify negative effect of inequality. Alesina and Rodrick (1994) show that inequality in land

¹⁵ Note that following the terminology commonly used in this literature, the term ‘growth’ may refer to growth during the convergence process, growth in the steady state, or to income levels in the steady state, depending on the context.

and income ownership is negatively correlated with subsequent economic growth. Alesina and Perotti (1996) test on a sample of 71 countries for the period 1960-1985 and find out that income inequality increases social-political instability and the instability reduces investment, thus income inequality and growth negatively related. Perotti (1996) identifies several channels through which the negative relationship between income inequality and economic growth exists. In particular, it shows that more equal societies have lower fertility rates and higher rates of investment in education, which is both reflected in higher rates of growth. In addition, very unequal societies tend to be politically and socially unstable, which is reflected in lower rates of investment and therefore lower growth. In a panel setting, Deininger and Olinto (2000) examine the robustness of relationship between inequality and growth using GMM estimator, and the evidence support for large negative impact of asset but not income inequality on subsequent growth. Persson and Tabellini (1994) find similar negative and strong link between inequality and growth in both historical panel data (9 developed countries) and postwar cross-sectional countries (56 countries), which only presents in democracies.

Compared to the bulk of studies that find negative link between inequality and economic development, fewer works show evidence supporting positive relationship, most of which estimate with panel data. Relying solely on system GMM estimation for 45 countries from 1966-1995, Forbes (2000) suggests that in the short and medium term, an increase in a country's level of income inequality has a significant positive relationship with subsequent economic growth. Li and Zou (1998) also show that income inequality is positively and most of time significantly associated with economic growth applying fixed effect and random effects models based on panel data of 217 observations covering 46 countries. Lundberg and Squire (2003) also show that equality possibly adversely influences growth in each specification for 38 countries since 1960. A recent work by Casey and Owen (2014) suggests that inequality is positively related to economic development and previous results indicating negative effects of inequality may be inadvertently capturing the impact of ethnic fractionalization¹⁶.

More literature gives mixed evidence, rather than sharp conclusions on the negative or positive impact of inequality on economic development as shown above. Some studies show that the link between inequality and economic development is not robust and shows insignificant coefficients. For example, Deininger and Squire (1998) show that initial income

¹⁶ This is one of the reasons I will control for ethnic fractionalization in the robustness check for omitted variables.

inequality is not a robust determinant of future growth, since adding region dummies leaves inequality insignificant. Another recent paper by Brzezinski (2013) also finds the insignificance of the impact of income inequality on growth. Nonlinearity of the impact of inequality on economic development may be one of the explanations that lead to insignificant overall effect. Banerjee and Duflo (2003) show that the growth rate is an inverted U-shaped function of net changes in inequality: changes in inequality in any direction are associated with reduced growth in the next period¹⁷. Another hypothesis is that the link between inequality and economic development depends on income levels. However, even among the literature providing evidence supporting the hypothesis, the results are not conclusive. Based on OLS regression, Barro (2000) shows that the impact of inequality on economic growth is negative for poor countries and positive for rich countries. In contrast, Galor and Moav (2004) argue that inequality stimulates economic growth in the early stages of development, when physical capital accumulation is the primary source of growth, since it channels resources towards individuals with a higher propensity to save. In the later stages of development, when human capital is the main engine of economic growth, the effect is reversed.

However, among the cross-sectional works, very few of them deal with endogeneity problem and most of them rely on OLS estimation. Easterly (2007) is one of the very few works that identify external instrument for income inequality and rely on IV regression to purge the causal link between inequality and economic development. Specifically, he uses land quality - the abundance of land suitable for growing wheat relative to that suitable for growing sugarcane - as an instrument for inequality and finds out high inequality to be a large and statistically significant barrier to prosperity, good quality institutions, and high schooling.

However, there is substantial evidence against the validity of land quality as a valid instrument for inequality. Firstly, Casey and Owen (2014) show that land quality proposed by Easterly (2007) may be just as good an instrument for ethnic fractionalization as it is for income inequality. Given that ethnic fractionalization is also a significant determinant of economic development controlling for inequality, the exclusion restriction is violated for land quality as a valid instrument for inequality. Secondly, the results of Easterly (2007) about the effect of inequality on current income are not robust to controlling for tropical location, which implies that land quality may be just proxying for tropical location. Since tropical location is argued in

¹⁷ Chen (2003) concludes with similar result that there is an inverted-U relationship between initial income distribution and long-term economic growth.

the literature that it affects income through social and political institutions (see for example Acemoglu et al., 2005a, b; Easterly and Levine, 2003; Rodrik et al., 2004), it again makes the validity of land quality questionable.

3.3 Methodology and results

The purpose of the paper is to reassess the impact of income inequality on economic development. However, the endogeneity issue may prevent us from getting reliable results from Ordinary Least Square (OLS) estimation. In particular, reverse causation, measurement error of income inequality and omitted variables all may contribute to the endogeneity issue. First, although we attempt to capture the causal link from income inequality to economic development, the evidence to support the reverse relationship is well documented in the literature (see Deininger and Squire (1998), Vanhoudt (2000) and Barro (2000)). So reverse causation may make OLS estimation biased, although the direction of bias depends on how economic developments affects income inequality. Second, the endogeneity may also come from uncontrolled confounding variables. Third, income inequality may be subject to measurement error, which will lead to attenuation bias in OLS coefficients. Therefore, a new set of instruments from Putterman and Weil (2010) are introduced to tackle with the endogeneity issue in the model by using Two Stage Least Square (2SLS) estimation. To provide comparable and convincing evidence, the main specification is based on the seminal work of Easterly (2007) who also attempts to investigate the overall effect of income inequality on economic development with another instrument, land quality. First, the selection of income inequality dataset is discussed. Secondly, the new instruments inspired by Putterman and Weil (2010) will be reviewed. Thirdly, the other variables and the summary statistics will be presented before the discussion of exclusion restriction and the empirical results.

3.3.1 Data

One of the most prominent measures of income inequality is Gini coefficient. There are various datasets of Gini coefficient across countries¹⁸. The database used in this study is called the

¹⁸ Deininger and Squire (1996) provide Gini observations across a large number of countries, but only at a substantial loss of comparability, since many are based on different income definitions (e.g., gross or net) and different reference units (e.g., households or persons). The Luxembourg Income Study (LIS) offers a smaller dataset mainly applying to rich countries and earns a reputation as the best data available for making cross-national comparisons of income inequality. Unfortunately, it is available for only 30 countries, almost all of which are among the richest. Drawing on both Deininger and Squire (1996) and the LIS, the World Income Inequality Database compiled by the World Institute for

Standardized World Income Inequality Database (SWIID), covering 153 countries, with 3,331 country-year observation on net inequality and 3,273 country-year observation of gross inequality for as many years as possible from 1960 to present. The advantage of the database is that it achieves balance between comparability and coverage by maximizing comparability of income inequality statistics for the broadest available set of observations¹⁹. To avoid noise problem, I take the average for each country of inequality measures over 1960–98, as does Easterly (2007). So each country has one observation for an averaged Gini coefficient.

Putterman and Weil (2010) shows that the heterogeneity in the early development experience of the ancestors of a country's current population is significantly related to current income inequality, thus suggesting a natural instrument for current income inequality. One of the contributions of their study is to construct a migration matrix accounting for large-scale population movements since 1500. Each entry shows the share of the year 2000 population in every country that is descended from people in different source countries back in the year 1500. Each row is for a present-day country, and each column is for a source country²⁰. Each row sums to one. They use two measures of early development. The first one is an index of state history called *statehist*. The index takes into account whether what is now a country had a supratribal government, the geographic scope of that government, and whether that government was indigenous or by an outside power. It is normalized to be between 0 and 1. For example, Ethiopia has the maximum value of 1. China and Egypt have relatively large value of 0.906 and 0.760. Spain, Mexico and Senegal have median values of 0.562, 0.533 and 0.398, while Canada, the U.S., Australia and New Guinea are among the countries with extremely small or even 0 *statehist* value. The second index is the number of millennia since a country transitioned from hunting and gathering to agriculture prior to 2000 called *agyears*. The four

Development Economics Research of the U.N. University (UNU-WIDER, 2008) provides the most comprehensive set of income inequality data available. However, the comparability, data quality and coverage problems still haunt the dataset. In particular, the details of the data are documented, including sources, income definitions, areas, population covered, and reference units. This information allows researchers to maximize comparability by choosing only those observations with identical values on these criteria. However, the most common combination includes just 508 different country-years in only 71 countries, discarding the vast majority of the information in the data set. In addition, there is wastage of information if researchers restrict to work only with identified "high quality" data, which is a small fraction (980 of a total 5067 reported Gini coefficients are identified as "high quality").

¹⁹ It employs a transparent procedure to increase the comparability of available cross-country inequality data, the detail of which could be found in Frederick (2009).

²⁰ The matrix is 165 by 172, each row for a present-day country and each column for the same 165 countries plus seven other source countries with current population of less than one half million.

Fertile Crescent countries (Israel, Jordan, Lebanon, and Syria) have the highest value 10.5, followed by Iraq and Turkey of value 10, Iran of value 9.5 and China of value 9. Countries like Ecuador and Congo are in the middle with value 4 and 3 respectively. New Zealand and Australia are at the bottom, since agriculture arrived late in these countries.

The original form of the two measures of early development is country-specific and it is adjusted in two ways using the matrix. For each country the entries of the corresponding row of the matrix are the weights used to get the weighted mean and standard deviation of *statehist* and *ageyears*. The weighted average of *statehist* and *ageyears* is to capture the average levels of the ancestry-adjusted early development and it is shown to be significantly and positively related to current income. They are denoted by *mean_statehist* and *mean_ageyears*. The weighted within-country standard deviation of *statehist* and *ageyears* is to measure heterogeneity in early development²¹. They are denoted by *st_statehist* and *st_ageyears*. As mentioned before, the two measures of heterogeneity have strong predictive power over current income inequality, as shown in the columns 1-4 of Table IX in their paper.

In Putterman and Weil (2010), the dependent variable is the Gini coefficient 2000-2004 or in the most recent decade using the data from the UN World Income Inequality Database. To check the robustness of the predictive power of the heterogeneity measures and to be in line with the measure of income inequality in Easterly (2007), I reproduce the columns 1-4 of Table IX by replacing the dependent variable with averaged Gini coefficient over 1960-1998 from SWIID database, which is shown in Column 3 and 5 of Table 3.2.

To be in line with Easterly (2007), the dependent variable is the logarithm of real GDP per capita of 2002. From section III.B of Putterman and Weil (2010), the weighted average level of early development is positively related to current income. Therefore when assessing the impact of inequality on current income with heterogeneity in early development as instrument, I will always control for the weighted average of early development.

Table 3.1 shows the summary statistics of the key variables. The mean of gross Gini is larger than that of the net Gini as expected, and the standard deviation of the former is slightly smaller than that of the latter. In terms of the instruments, the mean is close to the standard

²¹ See Putterman and Weil (2010) for a detailed description of the construction of the measures.

deviation for each early development index, suggesting that there is wide variation across countries for both instruments.

3.3.2 Intuitive explanation

Assuming the early developmental advantages/disadvantages proxied by *statehist* and *agyears* to be something that migrants bring with them to their new country, the ancestry-adjusted variables measure the average level and the variation of such advantages within a present-day country. As mentioned before, Putterman and Weil (2010) show that the average level of early development positively predicts current income and the heterogeneity in early development positively predicts current inequality. My following exercises will not only substantiate the latter hypothesis, but also take advantage of the strong correlation to capture the exogenous variation of inequality to assess the causal link between inequality and income. So the result premises on the validity of the new instruments. Let’s start from the intuitive explanation. Why shall we expect a strong correlation between heterogeneity in early development and current inequality, and why does it follow the exclusion restriction? This section is to provide intuition behind these.

Table 3.1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per capita	139	10148.12	12240.83	331.95	67504.60
Net Gini	139	38.76	10.72	19.74	66.35
Gross Gini	139	44.45	9.03	25.84	67.35
<i>mean_statehist</i>	139	0.52	0.22	0	0.96
<i>mean_agyears</i>	139	5.31	2.03	1.36	10.4
<i>st_statehist</i>	139	0.10	0.09	0	0.332
<i>st_agyears</i>	139	0.84	.82	0	4.21

First of all, I will provide explanation of the strong correlation between the heterogeneity in early development and current inequality. The most likely explanation is that people, whose ancestors were living in countries that developed earlier (in the sense of implementing agriculture or creating organized states), brought with them some advantages when they move to less early developed countries, such as human capital, knowledge, skills, culture, or institutions.

Hypothesis I: Economic advantages directly made some people more productive and richer.

If a country is populated by people with large variation of early development, it means that a group of people are descendants from the source countries that were more developed, while another group of people are from the source countries that were less developed. As mentioned before, the groups of people differed in their human capital, knowledge, skills, culture or institutions and carried those characteristics with them when they moved from the source countries to the new countries. When the groups lived and interacted together in the new country, the differences of the mentioned characteristics play an important role, especially in their economic activities. To put in other words, the advantages or disadvantages in terms of early development will be manifested in their economic activities. For example, the group of people from more developed source countries would be more advantageous in the organization of production as well as the technology and skills used in production. So it would determine initial endowments or income of the population. The more developed the source countries where the migrants were from, the more advantages they had in production, thus the richer they would be.

Hypothesis II: Other characteristics made the advantages persistent.

Some may argue that there is a spillover effect during the mixture of the different groups of people, which would diminish the divergence of the production capability and income level among the population. It is quite plausible, however, it still cannot eliminate the differences between different groups of people, especially when the difference is large (measured by *sd_agyears* and *sd_statehist* instead of *mean_agyears* and *mean_statehist*), given the persistence of some factors (e.g. that are related to the amount of time since a population group began its transition to agriculture), institutions, culture and human capital among people rather than places.

First, these characteristics have a high degree of persistence over generations. Experience living in settled agricultural societies conveys to individuals some cultural characteristics that are economically advantageous in an industrial society. Moreover, consciousness cultivated in state-formed countries informs people some advantages that help them percolate and climb up to the top of the income distribution. Therefore a country with individuals from more heterogeneous backgrounds in terms of their families' economic histories should *ceteris paribus* be more unequal.

Second, as argued by Putterman and Weil (2010), populations that are similar in the dimensions just listed may be more likely to intermarry and mix socially than populations that are diverse. This mixing could by itself reduce any inequality in the groups' initial endowments, and would also likely be associated with an absence of institutions that magnify ethnic, racial, or economic distinctions. Countries in which people feel a strong sense of kinship with other citizens might also be expected to redistribute income more actively or promote economic mobility.

Third, another argument from Putterman and Weil (2010) that could explain the persistence of the different characteristics is the situation in which people with high and low *statehist* level mixed together tended to occur in cases of colonialization or slavery, and that in these circumstances people with high *statehist* level were able to create institutions that enabled groups at the top of the income distribution to remain there.

In addition, the last part of Putterman and Weil (2010) provides empirical evidence that the advantages brought by people from more developed places will help them stay in upper distribution of the income ranking, so that we could see the direct link between heterogeneity of the population and inequality.

In a word, the advantages/disadvantages brought by the migrants are quite persistent. Combining the two hypotheses gives the proposal that heterogeneity in the population's historical agriculture and states development of the source country has a direct impact on income inequality, since on the one hand people who came from the areas that developed early evidently brought with them economic advantages that were conducive to higher income, and on the other hand people who moved from one region to another carried the human capabilities built up in the former area with them and more importantly they are persistent. A country made up of people who are more different in terms of *statehist* and *ageyears* will *ceteris paribus* have higher inequality. Consider two extreme cases, where one country is populated by people from the source countries of the same *statehist* level, and the other country is populated half by people from the source countries of the minimum *statehist* level and half by people from the source countries of the maximum *statehist* level. In addition, we assume that the average *statehist* levels of the two countries are the same. However, it is obvious that the heterogeneity of the *statehist* levels of the two countries differ, where the former has zero heterogeneity and the latter with high heterogeneity. Based on the two

hypotheses above, we would naturally expect that the income distribution is even in the former and inequality is severe in the latter, despite of similar means of income level.

Next I will discuss the exclusion restriction. Is there another channel other than inequality through which heterogeneity in early development will affect current economic development?

Heterogeneity in the population's historical background has impact on current development only through its impact on inequality. Specifically, as mentioned before, once migration took place, the heterogeneity will play an important role in determining the divergence of productivity and thus income of different groups of people. Therefore the income inequality pattern of the country will be formed immediately. A country made up of people with little or less difference of early development, would tend to be more equal, since their similar levels of early development will determine their similar levels of productivity and income. A country made up of people with huge difference of early development would lead to greater inequality, since the large heterogeneity would lead to divergence of productivity and income, and the pattern is persistent and not easy to erase.

A potential concern is that the instruments may be related to economic development through institutions. Given that institutions are determinants of economic development, it may violate exclusion restriction. However, both statistical evidence and intuitive explanation are against the hypothesis. In particular, the empirical evidence in Table 3.4 and Table 3.5 will show that the instruments are invalid for institutions. In addition, the first stage results are also very weak with counterintuitive coefficients. The intuition behind the hypothesis is also doubtful. As mentioned before, there is an immediate impact of the instruments on the distribution of income among the population. Given that it may take much longer time to make institutional mechanism to work, it is more likely that the instruments would first and directly work on inequality since its impact on distribution of endowments or income is more prompt. After that, income inequality may gradually affect institutions. But in this way it does not violate the exclusion restrictions.

How about the direct impact on current development? It is more likely that the weighted mean rather than the standard deviation of early development has a direct impact on current development, which is also empirically supported by Putterman and Weil (2010). The underlying hypothesis is that the weighted mean of early development determines the average development level of the population, which determines the human capability thus the

average income level, while the weighted standard deviation of early development influences the heterogeneity of the population in terms of the early development, which determines the distributions of income. That is why in the empirical part, the weighted mean of early development is always controlled for when assessing the impact of inequality on current income.

3.3.3 Results

Inspired from Putterman and Weil (2010), I will reassess the effect of inequality on current income using the heterogeneity in early development as instruments for inequality. First of all, the IV regression results will be presented as the baseline results on inequality and development. The first stage regression results will be included to provide the first glance of the strength of the predictive power of the new instruments on income inequality, confirming the result of Putterman and Weil (2010). In addition, the test for overidentification is provided. Second, the exclusion restriction will be tested. Next are the robustness checks.

3.3.3.1 Baseline results

Table 3.2 shows the baseline IV results when I use the heterogeneity in early development as instruments for income inequality. As introduced in Section 3.3.1, there are two indicators to measure heterogeneity in early development, the weighted standard deviation of *statehist* and *agyears*, denoted by *sd_statehist* and *sd_agyears*. Column 1 of Table 3.2 shows the OLS result, where inequality is negatively related to income. Column 2 and 4 give the IV regression results using *sd_statehist* and *sd_agyears* separately as instruments for inequality, controlling for the weighted average of early development separately, denoted by *mean_statehist* and *mean_agyears*. Column 6 gives the IV regression results including both instruments. Given that the two instruments capture the heterogeneity in early development from different aspects, one on state development and the other on agriculture development, we should include both instruments to identify the coefficients of inequality in the following models, so that the information contained in each of them is used. In sharp contrast with the OLS result and Easterly (2007), inequality is positively and significantly related to income and the coefficients are similar for all specifications. At the same time, the weighted averages of early development are significant and positive as expected in all specifications, which supports the argument in Putterman and Weil (2010) that the average level of the ancestry-adjusted early development measures are positively related to current income.

Table 3.2: Baseline result

VARIABLES	(1) OLS GDP	(2) 2SLS GDP	(3) First GINI	(4) 2SLS GDP	(5) First GINI	(6) 2SLS GDP	(7) First GINI
		Instrument: <i>st_statehist</i>		Instrument: <i>st_agyears</i>		Instrument: <i>st_statehist & st_agyears</i>	
GINI	-5.64*** (0.844)	8.17** (3.66)		7.82*** (2.98)		6.69** (2.88)	
mean_statehist		4.11*** (0.81)	- 0.15*** (0.04)			1.92** (0.77)	-0.01 (0.04)
mean_agyears				0.51*** (0.10)	- 0.03*** (0.00)	0.37*** (0.11)	- 0.03*** (0.00)
st_statehist			0.42*** (0.09)				0.51** (0.24)
st_agyears					0.04*** (0.01)		-0.01 (0.02)
Constant	10.67*** (0.345)	3.18* (1.71)	0.43*** (0.03)	2.73 (1.67)	0.50*** (0.02)	2.95* (1.57)	0.49*** (0.03)
Observations	139	139	139	139	139	139	139
R-squared	0.215		0.250		0.370		0.418
Robust regression-based F statistic		42.064		26.990		38.647	
Robust regression-based P value		0.000		0.000		0.000	
Wooldridge's robust score statistic		24.616		29.275		23.172	
Wooldridge's robust score P value		0.000		0.000		0.000	
First Stage-F stat			22.046		21.382		15.441
First Stage-F P value			0.000		0.000		0.000
Sargan chi-squared statistic						0.085	
Sargan chi-squared P value						0.771	
Basmann chi-squared statistic						0.082	
Basmann chi-squared P value						0.775	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The endogeneity test, including Wooldridge's robust score test and robust regression-based test, are performed to determine whether inequality is in fact exogenous or not. If the test statistic is significant, which is the case here, inequality must be treated as endogenous. Hence we should not take the OLS as the appropriate estimation strategy. Compared to the 2SLS

results, the OLS coefficients are downward biased, suggesting the existence of endogeneity from measurement errors.

From Column 3, 5 and 7, we could see that the F-statistics for the first stage regression are not only well above the critical values identified by Stock and Yogo (2002) as indicating a problem with weak instruments, but also above 10, which is the rule of thumb suggested by Staiger and Stock (1997). In addition, the instrument, *sd_statehist* or *sd_agyears*, is strongly and positively related to inequality, in line with the prediction of Putterman and Weil (2010) that the heterogeneity in early development is a significant determinant of current inequality. Therefore at the moment, given the first stage results, there is no sign of weak instruments.

In order to do the test of overidentification, the number of instruments should be larger than the number of endogenous variables. So the test result is only available in Column 6, where *sd_statehist* and *sd_agyears* are together as instruments for inequality. Sargan's (1958) and Basmann's (1960) chi-squared tests are reported. A statistically significant test statistic always indicates that the instruments may be invalid. Both Sargan and Basmann tests are insignificant, indicating that the instruments may be valid²².

As mentioned in Section 3.2, some studies find the link between income inequality and economic development differs in different income groups, but the results are not consistent. For example, Barro (2000) and Galor and Moav (2004) reach contradictory conclusions. The former concludes that inequality is beneficial in rich countries and harmful in poor countries, while the latter states the opposite. The following section could be seen as a test of the competing hypotheses. In particular, the full sample of 139 countries will be divided into two subsamples, rich and poor groups, according to the classification of the World Development Indicators²³. I will run the IV regression for each subsample and see if the estimated links between inequality and income differ.

Table 3.3 gives the subsample results using 2SLS estimation. The first two columns show second and first stage results in poor countries. Gini still remains positive and significant with

²² A more rigorous conclusion of the tests is that we fail to reject the exclusion restriction. Another concern about the strength of the test of overidentification is that it is based on the assumption that one of the instruments is valid.

²³ The classification of countries of the World Development Indicators includes four income groups: high, upper middle, lower middle and low income. The rich group consists of high and upper middle income countries, while the poor one consists of lower middle and low income ones.

similar magnitude in full sample estimation, indicating that inequality is beneficial to economic development in poor countries. However, for rich countries, the last columns show that Gini is insignificant with negative sign. For both groups, the first stage results are strong with large F statistics. I have also attempted to control for fractionalization, legal origins and tropical locations in the regressions above and the results are similar to Table 3.3. Therefore, the evidence indicates that the positive link between inequality and income level is significant and robust for poor countries. It is in line with the hypothesis of Galor and Moav (2004), which also identifies positive inequality–development link in poor countries. However, the link is fragile in rich countries, mostly insignificant, which may suggest that the positive link obtained in the full sample results is mainly driven by the poor countries.

Table 3.3: Subsample results

	(1)	(2)	(3)	(4)
	<u>Poor Countries</u>		<u>Rich Countries</u>	
VARIABLES	2SLS GDP	First GINI	2SLS GDP	First GINI
GINI	7.42*** (2.85)		-0.83 (1.38)	
mean_statehist	0.23 (0.52)	0.03 (0.04)	1.64*** (0.63)	0.04 (0.08)
mean_agyears	0.39*** (0.10)	-0.03*** (0.00)	-0.05 (0.06)	-0.01* (0.01)
st_statehist		0.37* (0.18)		0.83* (0.43)
st_agyears		0.01 (0.02)		-0.01 (0.04)
Constant	2.34 (1.55)	0.52*** (0.03)	9.15*** (0.69)	0.33*** (0.06)
Observations	68	68	71	71
R-squared	0.156	0.527	0.235	0.418
Robust regression-based F statistic	5.688		2.958	
Robust regression-based P value	0.020		0.090	
Wooldridge's robust score statistic	4.305		2.625	
Wooldridge's robust score P value	0.038		0.105	
First Stage-F stat		13.520		18.490
First Stage-F P value		0.000		0.000

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

3.3.3.2 Exclusion restriction

One of the most important concerns in each IV estimation is the exclusion restriction, which in this case is the requirement that the heterogeneity in early development does not affect

income directly or through any channels other than inequality. Unfortunately there is no direct and definitive testing for the exclusion restriction. However, we could still get some inference through various econometric tests. Assessing the other potential channels through which the instrument may affect income may be a helpful indirect test, which is of course far from definite as it is impossible to rule out every possible channel. The best we can do is to check the most suspicious channels to our best knowledge.

One of the main concerns on the validity of instrument is that it may work on current income through institutions. To assess this possibility, I estimate the equations from Table 3.2 using six different measures of institutional quality one at a time as endogenous variable and report the first-stage and second-stage results as well as various tests, as shown in Table 3.4²⁴. When we instrument institutional quality with heterogeneity in early development, more than half of the coefficients of instruments has unexpected positive signs and all are insignificant, implying the lack of strong correlation between the instruments and inequality. In addition, the F statistics for excluded instruments are extremely small for each institutional quality indicator, which is well below 10, suggesting that weak instrument problem is severe. Therefore the evidence indicates that it is very unlikely that within country heterogeneity affects income through institutions.

Another piece of evidence pointing to the unlikelihood of heterogeneity in early development working on current income through institutions is via the test of overidentificavalition as long as valid instrument for institutions is available. Fortunately, the literature offers potentially valid instruments for institutions. The legal origins (see Djankov et al. 2002, 2003; Acemoglu and Johnson, 2005) and ethnolinguistic fractionalization (see Mauro 1995) are generally accepted as valid instruments for institutional quality when assessing the causal link between institutions and development, we add them one at a time as additional instrument for institutions together with *sd_statehist* and *sd_agyears*, so that we can do the overidentifying test²⁵.

²⁴ The institutional quality indicators are from the World Bank Worldwide Governance Indicators (WGI) and they are Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, Control of Corruption. It is available from <http://info.worldbank.org/governance/wgi/index.aspx#home>, and I use the data of year 2002.

²⁵ The test of overidentification is based on the assumption that legal origins and ethnolinguistic fractionalization are valid instruments for institutions. So if the test is significant, it indicates that *sd_statehist* and *sd_agyears* are not valid instruments for institutions.

Table 3.4: Instrumenting institution quality indicators by st_statehist and st_agyears

VARIABLES	(1) 2SLS GDP	(2) First VA	(3) 2SLS GDP	(4) First PV	(5) 2SLS GDP	(6) First GE	(7) 2SLS GDP	(8) First RQ	(9) 2SLS GDP	(10) First RL	(11) 2SLS GDP	(12) First CC
mean_statehist	-0.17 (0.65)	1.10** (0.51)	-2.55 (4.57)	1.03** (0.50)	-4.96 (6.52)	1.82*** (0.50)	-1.23 (1.12)	1.43*** (0.51)	-2.40 (2.84)	1.82*** (0.48)	-1.53 (1.47)	2.04*** (0.49)
mean_agyears	0.18*** (0.06)	0.01 (0.05)	0.12 (0.17)	0.02 (0.05)	0.06 (0.18)	0.03 (0.04)	0.12 (0.08)	0.03 (0.04)	0.12 (0.09)	0.03 (0.04)	0.19*** (0.05)	-0.00 (0.04)
st_statehist		0.90 (1.97)		0.75 (2.34)		1.14 (2.42)		1.50 (2.20)		1.90 (2.26)		2.71 (2.43)
st_agyears		0.11 (0.20)		-0.00 (0.24)		-0.05 (0.24)		-0.01 (0.22)		-0.14 (0.22)		-0.16 (0.23)
VA	1.65*** (0.50)											
PV			4.28 (4.33)									
GE			3.82 (3.62)									
RQ							2.16*** (0.80)					
RL									2.45 (1.69)			
CC											1.76** (0.78)	
Constant	7.65*** (0.40)	-0.84*** (0.23)	9.83*** (3.32)	-0.85*** (0.27)	10.64*** (3.95)	-1.16*** (0.22)	8.38*** (0.70)	-1.00*** (0.24)	9.35*** (1.95)	-1.25*** (0.23)	8.34*** (0.82)	-1.19*** (0.24)
Observations	139	139	139	139	139	139	139	139	139	139	139	139
R-squared	0.406	0.097		0.061		0.183	0.059	0.136		0.168	0.264	0.159
Robust regression-based F statistic	4.309		11.277		14.006		8.253		4.027		3.492	
Robust regression-based Pval	0.040		0.001		0.000		0.005		0.047		0.064	
Wooldridge's robust score statistic	4.264		10.593		12.388		7.529		4.353		3.671	
Wooldridge's robust score Pval	0.039		0.001		0.000		0.006		0.037		0.055	
First Stage-F stat		3.000		0.366		0.381		1.697		0.466		1.070
First Stage-F P value		0.053		0.694		0.684		0.187		0.629		0.346

Note: VA is short for Voice and Accountability; PV is short for Political Stability and Absence of Violence; GE is short for Government Effectiveness; RQ is short for Regulatory Quality; RL is short for Rule of Law; CC is short for Control of Corruption; Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.5 shows the results when legal origins are used as instruments for institutions together with *sd_statehist* and *sd_agyears*²⁶. In the first stage results, legal origins are all significant with expected signs in each specification, confirming that they strongly predict current institutions. However, the coefficients of *sd_statehist* and *sd_agyears* have unexpected positive signs. In addition, the test of overidentification is significant at 5% level for every specification except for Voice and Accountability (VA). The failure of the test of overidentification together with the weak first stage results suggest that heterogeneity in early development may not be valid instrument for institution, thus making the possibility doubtful that they will affect current income through institution.

As mentioned before, Casey and Owen (2014) show that land quality proposed by Easterly (2007) may be just as good an instrument for ethnic fractionalization as it is for income inequality. Based on it, I have argued that the exclusion restriction is violated for the land quality as valid instrument for inequality. To make sure the new instrument is not vulnerable in the same way, I will test if heterogeneity in early development is also as good an instrument for ethnic fractionalization as it is for income inequality. In particular, I will run the regression of income on ethnic fractionalization, which is instrumented by heterogeneity in early development as shown in Table 3.6. Problems reveal in the first-stage results. On one hand, either of the two instruments is significant, implying the lack of strong correlation between the instrument and endogenous variable. On the other hand, the F statistic is insignificant, and well below 10, suggesting severe weak instrument issue. Moreover, in the second stage, the coefficient of fractionalization is insignificant, inconsistent with the evidence from the literature that ethnic fractionalization is a significant determinant of economic development. In one word, the new instruments are vulnerable in the same way as land quality, by showing that it is not an appropriate instrument for fractionalization.

²⁶ I have run the regression with use ethnolinguistic fractionalization as instruments for institutions together with *sd_statehist* and *sd_agyears*. The results are all similar with what are shown in Table 3.5.

Table 3.5: Instrumenting institution quality indicators by sd_statehist, sd_agyears and legal origins

VARIABLES	(1) 2SLS GDP	(2) first VA	(3) 2SLS GDP	(4) first PV	(5) 2SLS GDP	(6) first GE	(7) 2SLS GDP	(8) first RQ	(9) 2SLS GDP	(10) first RL	(11) 2SLS GDP	(12) first CC
mean_statehist	0.24 (0.40)	0.41 (0.48)	0.25 (0.37)	0.58 (0.50)	-0.15 (0.36)	1.06** (0.46)	-0.16 (0.39)	0.82* (0.49)	0.00 (0.38)	1.03** (0.44)	-0.07 (0.39)	1.13** (0.47)
mean_agyears	0.19*** (0.05)	0.07 (0.05)	0.18*** (0.05)	0.02 (0.05)	0.16*** (0.04)	0.11*** (0.04)	0.15*** (0.05)	0.08* (0.05)	0.16*** (0.04)	0.11*** (0.04)	0.18*** (0.04)	0.08* (0.04)
st_statehist		0.28 (1.89)		1.38 (2.30)		0.66 (2.23)		1.10 (2.06)		1.36 (2.11)		2.18 (2.30)
st_agyears		0.25 (0.19)		0.09 (0.23)		0.05 (0.22)		0.09 (0.21)		-0.03 (0.21)		-0.05 (0.22)
leg_british		-1.37*** (0.23)		-1.54*** (0.28)		-1.35*** (0.29)		-1.19*** (0.28)		-1.38*** (0.27)		-1.64*** (0.35)
leg_french		-1.53*** (0.20)		-1.63*** (0.24)		-1.75*** (0.26)		-1.46*** (0.24)		-1.78*** (0.22)		-1.96*** (0.31)
leg_socialist		-1.90*** (0.28)		-1.30*** (0.26)		-2.10*** (0.27)		-1.73*** (0.29)		-2.15*** (0.26)		-2.37*** (0.31)
VA	1.24*** (0.13)											
PV			1.38*** (0.14)									
GE					1.03*** (0.09)							
RQ							1.34*** (0.14)					
RL									1.00*** (0.09)			
CC											0.97*** (0.10)	0.60 (0.40)
Constant	7.38*** (0.21)	0.61** (0.30)	7.63*** (0.23)	0.64* (0.34)	7.68*** (0.20)	0.38 (0.34)	7.70*** (0.20)	0.31 (0.35)	7.72*** (0.21)	0.31 (0.32)	7.55*** (0.21)	0.60 (0.40)
Observations	132	132	132	132	132	132	132	132	132	132	132	132
R-squared	0.614	0.294	0.458	0.214	0.759	0.421	0.662	0.305	0.695	0.418	0.690	0.406
Robust regression-based F statistic	11.602		18.744		0.033		11.534		0.472		1.030	
Robust regression-based P value	0.001		0.000		0.856		0.001		0.493		0.312	
Wooldridge's robust score statistic	9.895		13.777		0.034		9.322		0.487		1.017	
Wooldridge's robust score P value	0.002		0.000		0.854		0.002		0.485		0.313	
Sargan chi-squared statistic	7.339		9.318		31.716		10.983		26.165		18.346	
Sargan chi-squared P value	0.119		0.054		0.000		0.027		0.000		0.001	
Basman chi-squared statistic	7.300		9.418		39.216		11.253		30.655		20.016	
Basman chi-squared P value	0.121		0.051		0.000		0.024		0.000		0.000	
First Stage-F stat		14.698		9.445		14.332		10.032		17.567		13.927
First Stage-F P value		0.000		0.000		0.000		0.000		0.000		0.000

Note: As in Table 3.4.

Table 3.6: Instrumenting fractionaliztion by st_statehist and st_agyears

VARIABLES	(1) 2SLS GDP	(2) First Fractionalization
mean_statehist	3.46** (1.66)	-0.23* (0.13)
mean_agyears	0.48* (0.25)	-0.03*** (0.01)
st_statehist		0.19 (0.45)
st_agyears		0.02 (0.05)
Fractionalization	7.87 (5.47)	
Constant	0.67 (4.17)	0.71*** (0.07)
Observations	137	137
R-squared		0.204
Robust regression-based F statistic	16.989	
Robust regression-based P value	0.000	
Wooldridge's robust score statistic	15.236	
Wooldridge's robust score P value	0.000	
First Stage-F stat		1.708
First Stage-F P value		0.185

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.3.4 Robustness checks

3.3.4.1 Omitted variables

Following Easterly (2007), robustness checks for some omitted variables are conducted, including controlling for ethnic fractionalization, legal origins, and tropical location. Table 3.7 shows the second-stage results when controlling for each of these in turn as exogenous and instrumenting inequality with *st_statehist* and *st_agyears*. The first-stage F statistics are above 10 when controlling for ethnic fractionalization and tropical location, and are smaller than 10 when controlling for legal origins²⁷. In addition, both Sargan test and Basmann test are insignificant, indicating that the instruments are still valid when the controls are included. The Gini coefficients are positive and significant in each specification, which is consistent with the baseline results. Moreover, all of the controls show expected signs and are significant. In particular, ethnic fractionalization and tropical location are negative and significant, implying that increasing fractionalization and more tropical land area will lead to underdevelopment. Dummies for British, French and Socialist legal origin all remain significant and negative,

²⁷ The first-stage results, including the significance of the instrument and the F statistic, and the R square are still satisfactory even though the F statistics are smaller than 10.

suggesting that German or Scandinavian legal origin (the omitted categories) has significant advantage to the other three legal origins in terms of the impact on income.

Table 3.7: Robustness check for omitted variables

VARIABLES	(1) 2SLS GDP	(2) 2SLS GDP	(3) 2SLS GDP
GINI	7.78** (3.04)	14.91** (6.73)	11.08*** (4.03)
mean_statehist	1.30 (0.80)	1.49 (1.05)	1.54* (0.89)
mean_agyears	0.31*** (0.11)	0.52*** (0.17)	0.33** (0.14)
Fractionalization	-2.68*** (0.62)		
Leg_british		-3.70*** (1.10)	
Leg_french		-3.95*** (1.12)	
Leg_socialist		-2.55*** (0.67)	
Tropics			-2.31*** (0.53)
Constant	4.32*** (1.54)	2.43 (2.62)	2.76 (1.96)
Observations	137	132	134
Robust regression-based F statistic	36.286	37.097	48.580
Robust regression-based P value	0.000	0.000	0.000
Wooldridge's robust score statistic	21.798	23.203	23.083
Wooldridge's robust score P value	0.000	0.000	0.000
Sargan chi-squared statistic	0.160	0.660	2.163
Sargan chi-squared P value	0.689	0.416	0.141
Basman chi-squared statistic	0.153	0.623	2.100
Basman chi-squared P value	0.696	0.430	0.147
First Stage-F stat	14.481	6.043	10.443
First Stage-F P value	0.000	0.003	0.000

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

3.3.4.2 Different inequality measure

The above analysis is based on the net-income-based inequality data, which is called net Gini. Another commonly cited inequality measure is gross Gini, which is gross-income based. The extent of the difference between the two depends on various factors, such as the degree to which taxes are progressive and government transferring income to the poor from the rich. Although the main interest is to assess the effect of net inequality on development, it would be an interesting attempt to see if there is a significant change of the baseline result if the gross inequality is used. The baseline regression result using gross Gini is very similar to that using net Gini, which are shown in Table 3.8. The first column gives baseline results, and the

remaining three columns have fractionalization, legal origins and tropical locations controlled for separately. In each specification, the Gini coefficients remain significant and positive. The controls are all significant with expected signs. More importantly, the results of various tests also hold. The first-stage F statistics are strong and significant. The endogenous tests are all significant, which suggests that inequality should be treated as endogenous. The tests of overidentification are all insignificant, implying valid instruments. In one word, the results suggest that the baseline results are not driven by the specific inequality data I choose. Both gross and net inequality is positively related to current income.

Table 3.8: Robustness check for gross Gini

VARIABLES	(1) 2SLS GDP	(2) 2SLS GDP	(3) 2SLS GDP	(4) 2SLS GDP
GINI	7.14*** (2.69)	8.18*** (2.79)	14.48*** (4.97)	11.04*** (3.27)
mean_statehist	1.81** (0.71)	1.33* (0.71)	1.78** (0.87)	1.48* (0.76)
mean_agyears	0.34*** (0.09)	0.29*** (0.09)	0.38*** (0.10)	0.31*** (0.11)
Fractionalization		-2.07*** (0.47)		
Leg_british			-2.37*** (0.53)	
Leg_french			-2.24*** (0.42)	
Leg_socialist			-0.90 (0.59)	
Tropics				-1.70*** (0.36)
Constant	2.57* (1.50)	3.51** (1.59)	0.87 (2.54)	2.01 (1.78)
Observations	139	137	132	134
R-squared	0.110	0.178	-	0.085
Robust regression-based F statistic	9.547	13.804	19.966	21.719
Robust regression-based P value	0.002	0.000	0.000	0.000
Wooldridge's robust score statistic	7.374	9.861	13.817	12.992
Wooldridge's robust score P value	0.007	0.002	0.000	0.000
Sargan chi-squared statistic	0.094	0.175	0.551	2.490
Sargan chi-squared P value	0.760	0.675	0.458	0.115
Basmann chi-squared statistic	0.090	0.168	0.520	2.423
Basmann chi-squared P value	0.764	0.682	0.471	0.120
First Stage-F stat	21.307	19.795	9.963	15.977
First Stage-F P value	0.000	0.000	0.000	0.000

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

3.3.4.3 Different current years

To be in line with Easterly (2007), the dependent variable is the real GDP data of year 2002. I will show below that the positive link between inequality and income still holds when the year is changed. Table 3.9 shows the results of the same specification in Table 3.2 under different years of income data. We could see that the year of the dependent variable does not have any significant effect on the results²⁸.

Table 3.9: Robustness check for different current years

VARIABLES	(1) 2SLS GDP_1998	(2) 2SLS GDP_2000	(3) 2SLS GDP_2005	(4) 2SLS GDP_2010
GINI	6.66** (2.62)	6.45** (2.64)	5.66** (2.58)	5.14** (2.45)
mean_statehist	1.85** (0.76)	1.87** (0.77)	1.81** (0.74)	1.75** (0.70)
mean_agyears	0.36*** (0.11)	0.36*** (0.11)	0.36*** (0.11)	0.36*** (0.10)
Constant	2.93** (1.42)	3.05** (1.43)	3.52** (1.40)	3.91*** (1.34)
Observations	137	137	137	137
Robust regression-based F statistic	39.689	39.331	36.858	34.111
Robust regression-based P value	0.000	0.000	0.000	0.000
Wooldridge's robust score statistic	22.335	21.880	21.116	20.723
Wooldridge's robust score P value	0.000	0.000	0.000	0.000
Sargan chi-squared statistic	0.144	0.212	0.388	0.655
Sargan chi-squared P value	0.704	0.645	0.533	0.418
Basman chi-squared statistic	0.139	0.205	0.375	0.635
Basman chi-squared P value	0.709	0.651	0.540	0.426
First Stage-F stat	19.566	19.566	19.566	19.566
First Stage-F P value	0.000	0.000	0.000	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.4 Mechanisms

In this section, I will test the mechanisms through which inequality affects current income. From the literature, there are a number of hypotheses identified as potential channels, such as political economic hypothesis, sociopolitical instability hypothesis, credit-market imperfection

²⁸ As the difference between the four specifications is just the year of dependent variable, the first stage results should be identical. Therefore we have the same statistics for the first-stage F tests for the four regressions.

hypothesis, saving rate hypothesis, endogenous fertility hypothesis²⁹. Before showing the methodology and the results, we will first discuss the intuitions behind each channel.

3.4.1 Intuition

Political economic channel is also referred to as redistributive median-voter channel³⁰. Consider a framework where fiscal policy is decided by majority voting. The higher the income of the median voter, which is the decisive voter, the lower the level of government redistributive expenditure will be. Given that government redistributive expenditure may be negatively related to growth, due to disincentive effects on investment and saving, a more equal economy should have lower government redistributive expenditure, thus more investment and growth. Perotti (1996) proposed a testable implication for the channel. In particular, the above argument suggests that the effect of the fiscal policy variable should be stronger in democracies, since in the long run fiscal policy reflects the preferences of the majority in democracies.

The intuition behind the sociopolitical instability approach is that greater inequality leads to more political instability by fueling social discontent, and greater political instability creates uncertainty and reduces investment and growth³¹. Alesina and Perotti (1996) test the channel first and their results support it.

Credit-market imperfection channel predicts that due to credit constraint, the poor's investment in human capital and physical capital will be affected, as the exploitation of investment opportunities depends on the income level³². Therefore, greater inequality adversely impacts investment and income. On the other hand, as Barro (2000) argued, there is an offsetting force under the assumption that a large setup cost is a premise in investment. According to Barro (2000), if a business is productive only if it goes beyond some threshold size and the setup cost is large in relation to median income, then a reduction in inequality will be harmful to overall investment. In this sense, it is a channel that predicts a positive effect of

²⁹ See Perotti (1996) and Castells and Royuela (2014) with surveys of the channels.

³⁰ See Perotti (1996), Alesina and Rodrik (1994), Bertola (1993), Perotti (1993), Persson and Tabellini (1994), Deininger and Squire (1998) and Clarke (1995).

³¹ See Alesina and Perotti (1996), Gupta (1990), Hibbs (1973), Venieris and Gupta (1986) and Perotti (1996).

³² See Aghion and Bolton (1992), Galor and Zeira (1993), Banerjee and Newman (1991, 1993), Barro (2000) Deininger and Squire (1998)

inequality on investment and growth. Since physical capital will be examined in the saving rate channel, in this channel we will focus on human capital.

Next is endogenous fertility channel³³. Perotti (1996) once showed that more equal societies tend to have lower fertility rates. Given the fertility rate is a negative determinant of income, we would expect that inequality will be harmful to current income through its impact on fertility rate controlling for the investment in education.

Saving rate channel was premised on Keynes' idea and pointed out by Barro (2000) that in a closed economy the average propensity to save increases with income level so that a redistribution of resources from rich to poor tends to lower the aggregate rate of saving. So greater inequality leads to more savings, thus more capital accumulation and growth. Combined with the setup cost hypothesis mentioned in the credit-market imperfection channel, inequality is potentially beneficial to investment.

It is an interesting attempt to check if inequality will work through Total Factor Productivity (TFP). Technology growth and efficiency are regarded as two of the biggest sub-sections of Total Factor Productivity. Given that income inequality is argued in the literature to have an impact on allocation of resources, we might expect that income inequality will be related to TFP. For example, Bourguignon (2004) argued that income inequality might trigger redistribution of wealth, which may produce favourable effect on economic efficiency and growth.

3.4.2 Methodology and Results

As discussed above, political economic channel could be tested by splitting the sample into democratic and undemocratic regimes to see if inequality's effects on income differ in democratic and nondemocratic subsamples³⁴. As Table 3.10 shows, inequality is negatively related to GDP in democratic subsample as predicted by the above argument, while it is positive in nondemocratic ones. The results confirm the political economic channel by

³³ See Galor and Zang (1997), Perotti (1996) and Barro (2000).

³⁴ Following Deininger and Squire (1998), a country is defined as democratic if its Gastil index of civil liberties is below 2 and vice versa.

identifying significant and negative relationship between inequality and income level in democratic countries and a contrasting positive link existing in nondemocratic countries³⁵.

As to the other five channels, a common approach will be applied to test if the impact of inequality on economic development is driven by the mechanism in question. In particular, we will first add the channel variable to the baseline regression as additional endogenous variable. If the Gini coefficients lose significance or remain significant but become smaller, and at the same time the channel variable becomes significant, it is the first sign that the income inequality may work on income level through this channel. Then we will continue to add interaction term of inequality with the channel variable. A significant interaction term may confirm the mechanism hypothesis.

In both specifications, the added channel variable and the interaction term are treated as endogenous. In the sociopolitical instability channel, the channel variable is Political Stability and Absence of Violence (PV), from WGI. Legal origins are commonly used as instruments for institutional quality indicators when assessing the link between institutional indicators and economic development. Therefore, PV is instrumented by legal origins in the 2SLS regression. In the credit-market imperfection channel, human capital is proxied by the average years of total schooling over 15 from the World Bank³⁶. The lagged schooling indicator of year 1970 is used as its instrument. In the endogenous fertility channel, fertility rate of year 1960 is used as the instrument for current fertility rate. Both are from the World Bank. In the saving rate channel, the investment rate from PTW 8.0 is the channel variable, and its lagged value of year 1960 is the instrument. In the TFP channel, the channel variable TFP is from Klenow and Rodriguez (2005), and instrumented by its lagged value in year 1960. *st_statehist* and *st_agyears*, the instrument of each channel variable, and their interaction terms are entered as instruments for interaction term of channel variable and inequality. For example, in sociopolitical instability channel, legal origins, *st_statehist*, *st_agyears* and their interaction terms are instruments of the interaction of PV and inequality.

³⁵ I have also run the regression by including the interaction term of Gini and democratic index mentioned above. The result is generally consistent with the subsample results. In particular, the interaction term is significant and the marginal effect of Gini on income level is negative in democratic countries and become positive in nondemocratic ones.

³⁶ Alternative measures, i.e. the percentage of population over 15 that have completed secondary school from the World Bank and human capital index from PWT 8.0, are also used to show the robustness of the results. The regression results based on the alternative measures are consistent with the ones in Table 3.11.

From Table 3.11, we could see that none of the interactions are significant. It suggests that the channels we just discussed are not successful in explaining the positive link between income inequality and economic development. However, we should be very cautious drawing any conclusions from the regressions above considering the validity and strength of the instruments of channel variable. Except for the sociopolitical channel, where legal origins are commonly accepted as valid external instruments for institutional quality, the other four channels all use lagged value of the channel variables as instruments, as valid external instruments are unavailable. Especially in the saving rate channel, the first stage F statistics are smaller than 10 in both specifications, which imply that the lagged value of investment rate may be a weak instrument for current investment rate.

Table 3.10: Political economic channel

VARIABLES	(1)	(2)
	Dem GDP	NonDem GDP
GINI	-5.66*** (1.45)	5.68*** (2.16)
mean_statehist	1.19 (0.84)	0.38 (0.49)
mean_agyears	-0.12* (0.07)	0.36*** (0.07)
Constant	11.52*** (0.92)	3.43*** (1.15)
Observations	47	89
First Stage-F stat	22.994	20.730
First Stage-F P value	0.000	0.000

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.11: The results for other five channels

VARIABLES	(1) Sociopolitical Instability		(2) Credit-market Imperfection		(3) Endogenous Fertility		(4) Saving Rate		(5) Total Factor Productivity	
	GDP	GDP	GDP	GDP	GDP	GDP	GDP	GDP	GDP	GDP
GINI	4.76** (1.873)	4.35** (1.88)	3.230** (1.323)	7.48 (8.10)	1.572 (1.208)	-0.28 (3.30)	9.951** (5.053)	3.43 (12.20)	-0.848 (1.396)	23.64 (16.22)
mean_statehist	0.27 (0.466)	0.28 (0.48)	1.901*** (0.626)	1.94*** (0.61)	-0.202 (0.479)	-0.06 (0.51)	1.863 (1.472)	1.80 (1.41)	0.693 (0.638)	0.770 (0.671)
mean_ageyears	0.28*** (0.076)	0.26*** (0.07)	0.0154 (0.0672)	0.03 (0.07)	-0.153** (0.0638)	-0.13* (0.07)	0.237 (0.201)	0.23 (0.19)	-0.0314 (0.0636)	0.00685 (0.0632)
PV	1.66*** (0.227)	1.55* (0.90)								
Gini**PV		0.22 (3.04)								
Schooling			0.433*** (0.0381)	0.62* (0.34)						
Gini* Schooling				-0.56 (0.90)						
Fertility					-1.100*** (0.126)	-1.25** (0.55)				
Gini* Fertility						0.55 (1.44)				
Investment							17.14** (7.078)	6.04 (26.27)		
Gini* Investment								23.95 (54.45)		
TFP									2.110*** (0.318)	3.745*** (1.228)
GINI* TFP										-4.083 (2.590)
Constant	5.27*** (1.000)	5.49*** (0.96)	2.819*** (0.851)	1.20 (3.43)	11.95*** (0.769)	12.21*** (1.01)	-1.576 (3.460)	1.46 (6.11)	-3.558* (2.017)	-13.73* (7.882)
Observations	132	132	115	115	137	137	96	96	68	68
R-squared	0.209	0.240	0.653	0.675	0.441	0.497			0.769	0.789
F stats of First-stage Gini equation	21.96	12.33	46.74	28.12	56.37	32.01	8.60	5.78	13.51	13.51
F stats of First-stage Channel equation	9.44	8.60	149.30	105.16	35.01	28.85	5.55	6.00	14.11	14.11
F stats of First-stage Interaction equation		6.06	19.95	19.95	26.33	26.33		2.92	17.42	15.37
Hansen-J	0.89	0.41	0.25	0.52	0.14	0.18	0.88	0.40	0.57	0.54

Note: PV is short for Political Stability and Absence of Violence; TFP is short for Total Factor Productivity; Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.5 Conclusion

Drawing on Putterman and Weil (2010), I have used heterogeneity in early development as instruments for income inequality to reassess the impact of inequality on current income. The paper shows the validity of the new instruments statistically and intuitively. Based on the new instruments, the cross-sectional IV analysis shows that inequality is positively related to current income for the full sample, which is in contrast with the results of Easterly (2007), who used another instrument which I have argued is problematic. When I divide the full sample into two subsamples according to the income level, the positive link between inequality and income remains for the poor countries, while the link is negative and mostly insignificant in rich countries, in line with Galor and Moav (2004).

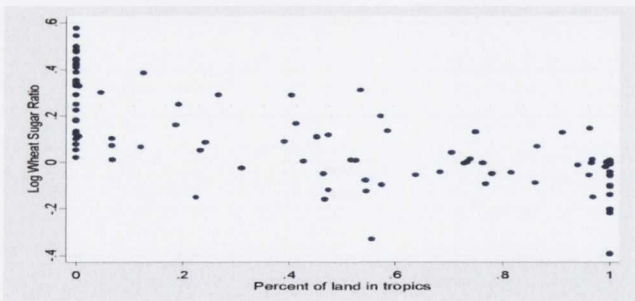
In addition, I have tested various hypotheses of the channels through which inequality impacts income. The results support the redistributive median-voter channel by confirming the negative link between inequality and income in democratic countries. However, the channels are not successfully explaining the positive link between income inequality and economic development. In the future work, it is worth exploring potential mechanisms to explain the positive link we identified.

Appendix to Chapter 3

Evidence against land quality as a valid instrument

As mentioned in the Introduction, one evidence against the validity of the land quality as valid instrument for inequality is the non-robustness of Easterly (2007)'s results. In particular, as a concern in Easterly (2007) as well, the instrument, which is the wheat-sugar ratio, could simply be proxying for whether the country is in the tropics³⁷, which is argued in the literature that may affect income through social and political institutions. If it is the case, the instrument is not valid. From Figure 3.1 and Table 3.12, there is a strong correlation between tropical location and the wheat-sugar ratio. In Easterly (2007), one of the robustness checks is to control for tropical location measure, and the tropical variable is not significant and inequality remains significant and negative. However, I will show that the result is not robust. In particular, I follow the specification of the robustness checks of tropical land of Easterly (2007) with improved inequality database SWIID and including more observations (extending from 95 to 110 countries)³⁸, the coefficient of inequality loses significance and the tropical variable becomes significant as shown in Column 2 of Table 3.13. It suggests that the results of Easterly (2007) about the effect of inequality on current income are not robust to controlling for tropical location. Therefore land quality may be just proxying for tropical location. In addition, from Column 4 which is the regression result of the reduced form, the F test of the instrument is not significant either, which also points to the issue of the problematic instrument.

Figure 3.1: Land quality and tropics



³⁷ As argued in Easterly (2007), tropical conditions are a major determinant of whether you can grow wheat (no) or sugarcane (yes).
³⁸ Since I am not able to get the country list of the 95 countries in the first specification of Table 9 of Easterly (2007), replication is not possible. Hence I could only run the regression on the largest set of countries I could get from the updated inequality database.

Table 3.12: Correlation between land quality and tropics

	Tropics	Land quality
Tropics	1.00	
Land quality	-0.72 (0.00)	1.00

Table 3.13: Effect of inequality on income controlling for share of tropical land

Dependent Variable	<u>Easterly (2007)</u>	<u>Replication</u>			
	2SLS	2SLS	First	Reduced	LIML
	GDP	GDP	GINI	GDP	GDP
	(1)	(2)	(3)	(4)	(5)
GINI	-0.11* (2.38)	-2.91 (2.33)			-2.91 (2.33)
Tropics	-0.24 (-0.54)	-1.47*** (0.40)	0.04 (0.03)	-1.58*** (0.37)	-1.47*** (0.40)
Wheat/Sugar			-0.29*** (0.06)	0.83 (0.70)	
Constant	12.42** (6.93)	10.33*** (0.73)	0.40*** (0.02)	9.17*** (0.27)	10.33*** (0.73)
Observations	95	110	110	110	110
R-squared			0.408	0.362	0.404
First stage-F stat	10.5		25.225		
First stage -P value of F stat			0.000		
F stat of instrument				1.412	
F stat P value of instrument				0.237	

Note: Instrument of inequality is land quality, which is from Easterly (2007) Appendix A. Share of tropical land is from Sachs and Warner (1997); Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Chapter 4 The Link between Human Capital Inequality and Human Capital Accumulation: Look through Two Channels

4.1 Introduction

Human capital matters in the process of economic development. First of all, it is well known that the level of human capital is an important component of wealth and growth. Klaus Schwab in the preface of The human capital report (2013) once mentioned “The key for the future of any country and any institution lies in the talent, skills and capability of its people.” It will determine the extent to which an economy could innovate and sustain long-term growth.

If an asset is not traded or is imperfectly traded, the marginal output of the asset across individuals or firms is not generally equalized (see Lopez et al., 1998). Therefore the aggregate output depends not only on the level of the asset but also on the distribution. Given the fact that human capital cannot be directly traded, or at least not perfectly traded, its distribution within a country should have an impact on the aggregate output level of an economy. Therefore, both the level and distribution of human capital play significant roles in the process of economic development. The importance of human capital inequality has been highlighted in the World Bank’s world development report (2006), “Equity and Development”, which moved for the first time beyond the question of income distribution, to emphasizing inequalities in key opportunity dimensions, including education. This paper aims to focus on the effect of distributional dimension of human capital. In particular, it is to investigate if human capital inequality has a significant impact on economic development through human capital accumulation. Most importantly, we are interested in the channels through which human capital inequality may influence human capital accumulation.

In the literature, there has never been short of studies on inequality and economic growth, both theoretical and empirical. The consensus among the theoretical studies is that inequality in wealth plays an important role in economic development. For a long period the scarcity of available data on the distribution of wealth across countries, causes most empirical studies to use income inequality to proxy for inequality and makes the traditional literature failed to capture the dimension of inequality in human capital. To gain a better understanding of the link between inequality and development, this paper contributes by focusing on human capital

inequality, which is measured by the Gini coefficient of educational distribution. In terms of data, Income inequality data suffers from several problems, which has been criticized by the researchers and is one of the reasons causing the estimated link between income inequality and growth weak and not robust. The indicator of human capital inequality is more accurate, consistent, comparable and of high quality than income inequality data (see Atkinson and Brandolini, 2001; Castelló-Climent, 2004, 2010a; Castello and Domenech, 2002).

Only a few papers have tried to investigate the channels through which human capital inequality affects economic development. This study contributes to the literature by considering two channels to explain the link.

First, the fertility channel predicts that an increase in human capital inequality leads to an increase in average fertility rate. In particular, parents with higher level of human capital find it optimal to have fewer children. Therefore a mean-preserving increase in human capital inequality will lead to higher fertility rate. As the total budget of a family is given, a higher fertility means less resources available to finance each child's education in the family. Therefore the fertility rate will have a negative impact on the human capital accumulation of the next generation. The empirical results confirms that human capital inequality is positively related to fertility rate and higher fertility rate will lower future human capital accumulation. The difference in the impact of inequality on fertility rates in rich and poor countries is also considered. The prediction is that reducing human capital inequality will lead to more human capital accumulation in rich countries given that the average level of education is higher and so the return to investing in human capital at low levels of education is higher than in poor countries where the average level of human capital is lower. The subsample results support the argument that the link is more significant in more developed countries. In addition, credit constraints are found to be the main channel through which higher fertility rates impact on human capital accumulation. The positive interaction term found in empirical results confirms that the negative effect of fertility on human capital accumulation would be stronger as people are less likely to borrow from the financial market to finance their children's education.

Second, it is predicted that an increase in initial human capital inequality will lower public spending on education. Although there are various popular topics about public spending on education, such as its determinants (e.g. Bussemeyer, 2007) and growth effect (e.g. Blankenau et al., 2007), to my best knowledge it is the first time that the channel is proposed to explain

the link between human capital inequality and human capital accumulation. Particularly, it is based on the idea that where human capital inequality is high there are likely to be barriers to or bias in education which lead to those with low human capital demanding less public expenditure on education given they benefit less from it. It could also be due to differences in preferences among the educated and uneducated with the latter are being more impatient and demanding subsidies and vouchers rather than investments in education whose return is more uncertain and take longer to realize. In the framework of median voter, the higher the human capital inequality, the less educated the median voter and the more likely they will vote against public spending on education. Based on the arguments above, we would expect the link to be stronger in democracies which better represent the median voter and reinforce the link between human capital inequality and public spending on education. We also expect the link should be found in nondemocratic countries. In particular, as human capital inequality increases, more human capital is appropriated by the elite. The government which is dominated by the elite would oppose more public spending on education to keep their resources as education is seen as a way of the poor eroding the elite's resources and authority. The empirical results not only show the negative link between human capital inequality and public spending on education, but also confirms the importance of democracy in the link.

In term of the implication for public policy, the importance of human capital inequality is also worth looking into thoroughly. Education is a major and important form of investment in human capital and equal access is among the basic human rights. The level of education people received may depend on various factors, including their own ability, parents' education and income, and government provision and allocation of education. The paper not only confirms that public spending on education affects the stock of human capital, but also predicts that human capital inequality is negatively related to human capital accumulation. Therefore government should value investment in education in general and at the same time allocate the source wisely to achieve more equal distribution of human capital.

The paper is organized as follows. Section 4.2 discusses related literature. Section 4.3 presents theoretical background. Section 4.4 talks about methodology and data first and then shows the results. A conclusion follows.

4.2 Related literature

As one of the most important research questions in macroeconomics, the link between inequality and economic development is what researchers are always trying to understand. Theoretical arguments preceded empirical works long ago and provided numerous mechanisms through which inequality may influence aggregate outcomes³⁹. Due to data availability, our knowledge of the link from the real world is mainly from income inequality, which has been intensively studied in recent decades. Whereas many theoretical models predict that too much inequality is harmful for growth, the cross country empirical evidence that uses income inequality measures is not conclusive on this matter, different specifications and different econometric techniques display different results. Alesina and Rodrick (1994), Alesina and Perotti (1996), Persson and Tabellini (1994) and Perotti (1996) are among the early cross-country growth regressions that identify negative effect of inequality. In addition, they also attempt to test the channels through which inequality may affect economic development. For example, Perotti (1996), Croix and Deopke (2003) and Galor and Zang (1997) identified fertility channel, through which more equal societies have lower fertility rates and higher rates of investment in education or physical capital, which is reflected in higher rates of growth. Both Perotti (1996) and Alesina and Perotti (1996) find out that income inequality increases social-political instability and the instability reduces investment, thus income inequality and growth negatively related. On the contrary, some works suggest a positive relationship between inequality and economic growth. Forbes (2000) suggests that in the short and medium term, an increase in a country's level of income inequality has a significant positive relationship with subsequent economic growth. Li and Zou (1998) also show that income inequality is positively and most of time significantly associated with economic growth applying fixed effect and random effects models based on panel data of 217 observations covering 46 countries. Lundberg and Squire (2003) also show that equality possibly adversely influences growth in each specification for 38 countries since 1960. In addition, there are evidence suggesting nonlinearity. Banerjee and Duflo (2003) show that the growth rate is an inverted U-shaped function of net changes in inequality. Both Barro (2000) and Galor and Moav (2004) provide evidence that the link depends on income level⁴⁰. In sum, empirical literature gives mixed evidence on the link between income inequality and economic growth.

³⁹ See the comprehensive survey in Voitchovsky (2009).

⁴⁰ However, the two paper come to opposite conclusions. Barro (2000) shows that the impact of inequality on economic growth is negative for poor countries and positive for rich countries. In contrast,

While the data of human capital inequality became available recently, there were several theoretical works pointing to the importance of human capital inequality. Galor and Tsiddon (1997) and Lopez et al. (1998) are among the earliest theoretical studies that assess the link between human capital inequality and economic development. The former analyses the interaction between the distribution of human capital, technological progress, and economic growth. It argues that the composition of human capital is an important factor in the determination of the pattern of economic development. In particular, it demonstrates that the evolutionary pattern of human capital distribution, the income distribution, and economic growth are determined simultaneously by the interplay between the parental level of human capital and the average level of human capital in society. Parents have a dual effect on the incentives of their children to invest in human capital. Parents affect their children directly through a home environment and indirectly by their contribution to the average level of human capital in the society as a whole, which in turn affects the magnitude of the labor augmenting technological progress in the next period. This technological progress increases the rate of return on investment in human capital for the children's generation and consequently stimulates further investment in human capital. The latter constructs an asset allocation model that elucidates the importance of the distribution of education to economic development. They show that the distribution of education is related to technological progress and industrial upgrading. The estimation of return to education is another strand of works under human capital theory and even precedes the studies on the distributional effect. The seminal work of Psacharopoulos and Patrinos (2004) has provided a literature review on the return to investment in education, which suggests that the classic pattern of falling returns to education by level of economic development and level of education are maintained. In addition, it concludes that investment in education behaves in a more or less similar manner as investment in physical capital, and in advanced industrial countries, the returns to human and physical capital tend to be equated at the margin.

Unlike income inequality literature, most empirical studies agree that human capital inequality is significantly and negatively related to economic development, although the measures of human capital inequality may vary. Birdsall and Londono (1997) finds that the standard deviation of human capital has a negative relationship with per capita growth based on a

Galor and Moav (2004) argue that inequality stimulates economic growth in the early stages of development.

cross-sectional data set of 43 countries. Park (2006) differs from Lopez et al. (1998) in that it investigates the influence of human capital dispersion on output growth per labor rather than the level of output and extends the work of Birdsall and Londono (1997) with an empirical study driven by a theoretical consideration of endogenous growth with human capital spillovers based on much richer set of data. As Park (2006) focuses on the degree of dispersion rather than the inequality in human capital, variance measure of educational attainment is utilized rather than Gini coefficient. These are two very different measures, which serve different research questions. The former will effectively reflect the degree of dispersion, which considers the homogeneity of human capital in terms of education attainment, while the latter is a measure of human capital inequality and accounts for the degree of disproportionate distribution of education by quintiles of population. It may explain why the study gives opposite results compared to the other studies using Gini measures, which finds that dispersion index positively influences productivity growth. Thomas et al. (2001) and Castello and Domenech (2002) find negative influence of human capital inequality on growth based on human capital Gini coefficient. The latter finds the negative relationship exists not only through the efficiency of resource allocation, but also through a reduction in investment rates. It also demonstrates that human capital inequality measures provide more robust results than income inequality measures in the estimation of standard growth and investment equations⁴¹.

Several channels are proposed through which human capital inequality may affect economic development. Evidence from Castello (2004) gives support to channels that connect human capital inequality with fertility decisions and to mechanisms that relate inequality and investment rates when individuals are credit constrained. Castello and Domenech (2008) presents a model in which inequality affects per capita income when individuals decide to invest in education taking into account their life expectancy, which depends to a large extent on the human capital of their parents. In particular, they consider that life expectancy will depend on the socioeconomic status of the family in which the individual is born into and, more specifically on the human capital of their parents, an assumption supported by empirical evidence (see for example Case et al., 2002; Currie and Moretti, 2003). The empirical evidence suggests that the life expectancy mechanism explains a major part of the relationship between

⁴¹ Birdsall and Londono (1997) also find out that after controlling for the initial distribution of human capital, income inequality itself is no longer statistically significant.

inequality and human capital accumulation. Castello (2010a) reveal that, all other things being equal, a greater degree of human capital inequality increases fertility rates and reduces life expectancy, which in turn hampers the accumulation rates of human capital. This effect is reinforced in the countries where individuals find it difficult to access credit. This paper improves on Castello (2010a) by finding out that the link between inequality and fertility rate is stronger in rich countries and specifying how credit constraint plays the role. Castello (2010b) shows different effects of inequality on growth depending on the level of development of the region. Specifically, it finds a negative effect of income and human capital inequality on economic growth, both in the sample as a whole and in the low and middle-income economies, an effect that vanishes or becomes positive in the higher-income countries.

Rodríguez and Tselios (2010) provides evidence in support of Castello (2010b)'s finding by examining the relationship in rich countries, western Europe in specific using regionally aggregated microeconomic data for more than 100,000 individuals over a period of 6 years. The results indicate that, given existing levels of inequality, an increase in a region's income and educational inequality has a significant positive association with subsequent economic growth.

4.3 Theoretical background

Two channels are discussed to explain the link between human capital inequality and human capital accumulation. One is the fertility channel, which predicts that initial human capital inequality has a positive relationship with fertility rate, which impedes human capital accumulation of the next period. The other is through public spending on education. An increase in initial human capital inequality will lead to a fall in public spending on education, which is harmful to human capital accumulation.

4.3.1 Fertility channel

The link between fertility decision and human capital is well documented in the literature and they are related in both directions. Theoretical and empirical studies agree on the fact that the human capital of parents will influence their fertility decisions. For example, the seminal work Becker et al. (1990), argues that parents with higher level of human capital find it optimal to have fewer children. Parents will decide how many children to have, considering the direct cost of raising children and the opportunity cost of their own human capital. Particularly, an increase in the human capital of the parents will have two offsetting effects on fertility, i.e.

income effect and substitution effect. Income effect predicts higher fertility rates, since the increase in the human capital of the parents will lead to an increase in their income, thus higher demand for children. Substitution effect implies lower fertility rates, since the increase in human capital will increase the opportunity cost of raising children, thus lower demand for children. At low levels of human capital, income effect dominates, as the direct cost of raising children is the main component of the total costs, inclusive of the opportunity cost. At high levels of human capital, substitution effect prevails as the opportunity cost increases and the direct cost becomes a relatively small part of total costs. Perotti (1996) explains why there is a positive relationship between inequality of parents' human capital and average fertility rate. Specifically, assume a redistribution of human capital from more educated parents to less educated ones (i.e. inequality decreases) and suppose that substitution effect prevails. He argues that as long as the demand for children is sufficiently elastic to human capital at low levels of human capital, the demand for children of the less educated would fall more than the increased demand for children of the more educated. Therefore, the average fertility rate decreases when inequality of human capital decreases and vice versa.

There is another link between fertility and human capital from another direction. In particular, a higher fertility rate is at the expense of lower investment in child education due to dilution effect (Blake, 1981; Galor and Zang, 1997; Perotti, 1996). In particular, the total budget of a family is given, a higher fertility means less resources available to finance each child's education in the family. Therefore the fertility rate will have a negative impact on the human capital accumulation of the next generation.

Perotti (1996) found that the effect of income inequality on fertility rate is related to income levels, with coefficient of income distribution in the sample of rich countries is about twice as large as of poor countries. However, his argument focuses on human capital inequality instead of income inequality. Particularly, his reasoning is based on Becker et al. (1990), whose crucial argument is that returns to education are low when the average level of human capital is low, which is particularly true in poor countries. In richer countries, the returns to investment in education at low levels of human capital are higher, and therefore fertility is more responsive to a redistribution of human capital to the poor. In fertility literature, it is not difficult to find other theoretical support for this hypothesis. Cochrane (1979; 1988) and Cleland and Rodrigues (1988) show that, at low levels of development, the main effect of formal education is to erode traditional restraints and thereby raise fertility, while its main effect at higher levels

is to decrease fertility by reducing the desire for children, which is expressed in the use of birth control. Although Perotti (1996) observed the different roles fertility channel played in rich and poor countries, as mentioned above he was using income inequality data on a small sample to test it, although his argument was based on human capital inequality. Castello (2010a) attempts to test the link by using human capital inequality data, however, his sample of rich countries only has 28 countries. Therefore it's worth reassessing the link to see if human capital inequality plays a more important role in rich countries than poor countries in the fertility channel as predicted on a broader sample based on human capital inequality data.

As to the second part of the channel, which links fertility rate and future human capital accumulation, credit constraint should play a significant role. In particular, financial development should measure to what extent people are able to borrow from the financial market to investment education. In a more constrained financial market and other factors held fixed⁴², the negative effect of fertility on human capital accumulation would be stronger as people are less likely to borrow from the financial market to finance their children's education.

Thus in the next session, several hypotheses will be tested. Firstly, we will test if other things being equal, an initial distribution of education will affect future average fertility rates and if the effects differ in rich and poor countries as expected. Secondly, the link between the fertility rates and human capital accumulation of next generation will be assessed. In addition, we are interested to see if credit constraint matters.

4.3.2 Public spending on education

To my best knowledge, no one has investigated the channel through which human capital inequality will influence public spending on education, which is related to human capital accumulation⁴³. As public spending on education is a particular category of government redistributive spending, this channel is closely related to fiscal policy approach in the literature that attempted to explain the link between income inequality and growth via its impacts on total government redistributive expenditures or taxations⁴⁴. Despite of the fact that the link between income inequality and total government redistributive expenditure is inconclusive in

⁴² Particularly, public spending on education will be controlled for, as it captures public resources people could resort to.

⁴³ Human capital inequality may well impact private spending on education. However, due to lack of data on private spending on education across countries, this channel would not be discussed here.

⁴⁴ Mello and Tiongson (2006) and Bae (2015) has provided detailed literature reviews on the link between income inequality and redistributive spending.

the literature, it could shed light on the channel of public spending on education. Studies that find positive relationship usually argue through the median voter theorem. Drawing on the seminal work of Meltzer and Richard (1981), several inequality studies show that more income inequality leads to larger redistributive government spending (see Romer, 1975; Easterly and Rebelo, 1993; Sylwester, 1999; Perotti, 1996; Alesina and Rodrik, 1994; Persson and Tabellini, 1994; Milanovic, 2000). According to Meltzer and Richard (1981), the demand for redistribution is a function of the individual's distance to the mean income. The poorer the median voters, resulting from higher inequality, the more they will demand for high levels of total redistribution and taxation. Therefore, a positive relationship between inequality and total redistribution would be expected at least in democracies.

In contrast, lots of cross-country studies disagree with the expectation of median voter theorem and find negative relationship (see Kaplan et al., 1996; Bradley et al., 2003; Watson and Ovseiko, 2005; Iversen and Soskice, 2006, 2009; Moene and Wallerstein, 2001, 2003; Cantillon, et al. 2003). Moene and Wallerstein, 2001) justifies the negative link based on social insurance theory. Particular, they argue that welfare expenditures are not only redistributive but also provide insurance against income loss. As income decreases, the demand for insurance decreases. A decrease in insurance demand will eventually lead to a decrease in social expenditure because the model assumes social expenditure as a public supply of insurance. Rodriguez (1999) justifies the negative link focusing on political economy factors. Due to rent-seeking and political influence, he showed that more inequality translates into an increased share of public resources accruing to individuals who are in a position to influence policy makers. As shown in the political economy-growth literature, organized individuals in unequal societies pursue their interests outside the usual channels of political representation (Alesina and Perotti 1994, 1996), thereby weakening the median voter hypothesis. Similarly, Lee and Roemer (1999) showed that public spending is not necessarily increasing in inequality when there is a class of individuals who cannot invest beyond the state-financed education, possibly due to the imperfection in capital market. They show that when the median voter does not make a private investment, equilibrium public spending is decreasing in inequality. We could also find empirical evidence supporting the negative link. Mello and Tiongson (2006) were interested in comparing social expenditures of unequal versus equal societies. Using cross-country data, they found that societies with low inequality have greater social expenditure using the ordinary least square and Tobit models. Iversen and Soskice (2009)

pointed out that in contrast to what Meltzer and Richard (1981) argued, data for advanced democracies consistently show equality in market income to be associated with high redistribution. They state that institutions that promoted equality in the distribution of wages co-evolved with institutions that promoted redistribution, thus producing the pattern we observe today.

There are also studies that support negative link between income inequality and public spending on education in particular. Watson and Ovseiko (2005) stated that "societies that permit large disparities in income to develop also tend to be the ones that underinvest in human capital (e.g. education)." Kaplan et al. (1996) have demonstrated striking correlations between the degree of income inequality at the state level and indicators of human capital investment. States with high income inequality spent a smaller proportion of the state budget on education and showed poorer educational outcomes, ranging from worse reading and mathematics proficiency to higher high school dropout rates. However, these works assess correlation instead of causation.

Bearing in mind that we are trying to understand the link between human capital inequality and public spending on education, the arguments above based on income inequality and total redistributive spending may not necessarily hold. It is more likely to observe a negative relationship between human capital inequality and public spending on education due to the following reasons.

One of the arguments that directly predict a negative link between inequality and public spending on education could be found in Busemeyer (2012) and Ansell (2008), which argue that high human capital inequality may imply a barrier of access to education. In particular, the existing barrier makes sure that the well-off and educated group will benefit disproportionately more from the existing education resources. If human capital inequality is high, the poor and less educated will be more opposed to increasing public spending on education, considering the barriers to education will prevent them from benefiting proportionally from the public spending on education.

Another argument points to the bias in public spending on education. In particular, it has been argued extensively in the literature that the public spending on education, far from being uniform, is biased in favor of the rich and highly educated group (See Birdsall, 1996; Addison and Rahman, 2001; Gradstein, 2003). The consequence of the hypothesis is similar to the

argument above. Given the bias of the allocation of public spending on education, if human capital inequality is larger, the less educated median voter may vote against more public spending on education.

In micro-level, several arguments also support that higher human capital inequality leads to smaller public spending on education. Firstly, education background is strongly related to preference on education spending (Busemeyer, 2012). In particular, the longer an individual stayed in school or university, the more support for increasing education spending. In addition, they have an informational advantage over less educated individuals in navigating the obstacles of the education system, and they are also more politically organized and articulate than less educated constituencies. Therefore in the median voter framework, the higher the human capital inequality, the less educated the median voter and the less they will support public spending on education.

Next, public spending on education stands out from other redistributive spending as return to education is not immediate and uncertain. People's current preference over education depends on their expectation of the future return of education. According to Becker and Mulligan (1997), a higher level of education means less "defective recognition of future utilities", bringing about a smaller discounting rate. Lawrance (1991) also finds a strong negative correlation between rates of time preference and education level. Fisher (1930) noted that small income levels would lead to high discount rate, partly from "lack of foresight and self-control" and partly because agents would think that "provision for the present is necessary both for the present itself and the future as well". Therefore time preference is not constant across levels of education and income, with less educated people discounting future consumption at a higher rate than better educated people (see Ventura, 2003). To put it in other words, the less educated are more impatient and value more current utility from immediate redistributive benefit, such as direct subsidies and vouchers, other than future utility from returns to education. According to the argument above, higher human capital inequality may cause the less educated median voter to choose away from public spending on education.

Based on the two arguments above, democracy should play a significant role in the link, in addition to its direct and positive impact on redistribution (see Acemoglu et al., 2013). In particular, in a more democratic country, the negative link between inequality and public

spending on education could be stronger. The reason is that the more democratic a country, the more the system empowers the median voter, who is more(less) educated in a less (more) unequal country, and more (less) supportive of public spending on education. Essentially, democracy empowers the median voter and reinforces the link between inequality and public spending on education by making their willingness more likely to realize.

While some of the arguments above may only hold in democracies, in nondemocratic countries, a negative link between human capital inequality and public spending on education may be expected with less surprise. Particularly, the policy maker does not represent the willingness and preference of majority. Instead, in most of the case the education policy is determined by an elite group, who are usually richer, more educated and politically powerful. A mean preserving increase in human capital inequality implies that more human capital is appropriated by the elite group, who would like to keep it in this way and maintain the elitist system and relatively superior class position by minimizing social mobility and preventing the poor eroding their power through education. So they would oppose more public spending on education to keep the poor and less educated remain poor and less educated. They won't worry about the education opportunity of their own offspring affected as private education investment is always affordable for them, while the education opportunities of the poor and less educated are significantly affected due to credit market constraint, which is exactly what the elite group wish to achieve.

The second part of the mechanism predicts a less controversial link between public spending on education and human capital accumulation. Particularly, we expect that more public spending on education in current period would increase the human capital accumulation of next period, other things being constant. Therefore together with fertility rate, public spending on education is a determinant of human capital accumulation.

4.4 Empirical results

4.4.1 Estimation strategy

The paper is to estimate the link between human capital inequality and human capital accumulation by assessing two potential channels, i.e. fertility and public spending on education channel. As shown in the last section, two stages are involved in both channels in order to tackle with the endogeneity issue. In the first stage, initial human capital inequality is related to the period-average fertility rate and public spending on education, which in the

second stage will relate to human capital accumulation. There is a time lag of the effect of fertility and public spending on education on human capital accumulation. Particularly, as a traditional setup of theoretical models of fertility⁴⁵, each individual is assumed to live for two generations, childhood and adulthood. Fertility decision is made in the beginning of the adulthood and how much they spend on their children's education will be affected in the current period. When the children progress from their childhood to adulthood, the human capital stock of next period is thus affected by the fertility decision of their parents from the last period. Similar argument holds in the case of public spending on education. We also expect that public education expenditure is related to human capital accumulation of the next period⁴⁶. As a result, the period 1960-2010 will be divided into two sub-periods⁴⁷, so that in each channel there is a two-equation system corresponding to the two periods. Two equation system is widely used in the inequality literature to assess the channels which involves two stages (see Perotti, 1996; Sylwester, 1999; Castello, 2010a), so that the estimated coefficient of the education inequality captures the causal link running from education inequality to human capital accumulation.

In the first sub-period, 1960-1990, the first stages of the two channels are assessed to see if initial human capital is related to fertility rate and public spending on education as shown in Equation (1) and (2). Equation (1) states that the inequality human capital inequality together with other control variables (denoted by X) is related to the period-average fertility rate. From the argument in Section 4.3.1, the parameter of interest is a_1 , and we expect it to be positive as higher initial inequality will lead to greater future fertility rate. In Equation (2), initial human capital inequality is linked to future public spending on education (denoted by PSE), with b_1 expected to be negative. At the same time, as argued in Section 4.3.2, democracy (denoted by DEM) should play an important role in the link, in addition to its direct and positive impact on redistribution. We expect a_2 to be positive, as democracy empowers the median voter and reinforces the link between inequality and public spending on education by making their willingness more likely to realize. We also will control for other determinants of public spending on education, denoted by Z .

⁴⁵ See, for example, Barro and Becker (1989) and Kalemli-Ozcan (2003).

⁴⁶ See Sylwester (1999).

⁴⁷ Table 4.9 in the appendix will show that if we equally divide the sample into two sub-periods, i.e. 1960-1985 and 1985-2010, the results won't change significantly. Table 4.10 in the appendix will show that if we divide the sample into 1960-1980 and 1980-2010, the results still hold.

$$FERTILITY_{6090} = a_0 + a_1 INEQUALITY_{60} + a_2 X + v \quad (1)$$

$$PSE_{6090} = b_0 + b_1 INEQUALITY_{60} + b_2 DEM + b_3 INEQUALITY_{60} * DEM + b_4 Z + \gamma \quad (2)$$

In the period 1990-2010, the second stage is tested. Particularly, we are interested to see if the fertility rate and public spending on education of the last period, 1960-1990, will affect human capital accumulation of 1990-2010 as shown in Equation (3). As we cannot rule out the possibility that inequality may affect human capital inequality directly or through other channels, initial human capital inequality should be included as a regressor in Equation (3).

$$H_{9010} = c_0 + c_1 FERTILITY_{6090} + c_2 PSE_{6090} + c_3 INEQUALITY_{60} + c_4 W + \epsilon \quad (3)$$

The three equations above define a recursive system. If the error terms are uncorrelated, applying OLS to each equation is both a consistent and efficient method of estimation. As the explanatory variables are measured with a considerable number of lags given the length of each period, the possibility of having correlated error terms and simultaneous bias are small. Therefore applying OLS to each equation should be both a consistent and efficient method of estimation. In addition, as a robustness check we also apply the Seemingly Unrelated Regression (SUR) estimation to jointly estimate the equations as a system, which takes into account possible cross-equation error correlation. The SUR is more efficient than single equation OLS as it uses all the information. However, the disadvantage of the method is that it will influence the results in all the equations if there is any misspecification in any one of the equations.

4.4.2 Data

In line with the inequality literature, human capital inequality is proxied by the Gini index of education as a measure of the distribution of years of schooling⁴⁸. It is equal to one half of the mean difference between all pairs of observations, divided by mean. The difference between income Gini and education Gini is that educational attainment is discrete, while income is continuous. We are using the data from Wail Benaabdelaali et al. (2012), which improves upon existing datasets in several aspects⁴⁹. First, it is calculated based on the most updated educational attainment data from Barro and Lee (2010), whose estimation is more accurate,

⁴⁸ Thomas et al. (2001) is the first that developed a Gini coefficient applied to education based on school attainment.

⁴⁹ See Wail Benaabdelaali et al. (2012) for discussion and comparison of existing datasets on education inequality.

while most of the existing datasets of human capital inequality were based either on Barro and Lee (1996, 2001) or on Cohen and Soto (2007) datasets. Second, it is constructed with seven levels of education, while most of the other studies used only four levels of education. The advantage of using seven levels of education is to enable us to differentiate between those who actually completed a level of education and those who did not.

To follow well-established literature on human capital (e.g. Card, 1999; Krueger and Lindahl, 2001; Acemoglu and Angrist, 2000; Acemoglu, 2009; Acemoglu et al., 2014), average years of schooling of the population above 15 years of age is used to proxy for human capital, which comes from the most updated version of Barro and Lee (2013). The period average years of schooling from 1990 to 2010 is obtained to proxy for the averaged human capital stock.

Fertility rate, which is measured by the total births per woman, is from the World Bank World Development Indicators. The data of public spending on education is from Barro and Lee (1994), which is quinquennial data for the years 1960-1985⁵⁰. Private credit by deposit money banks and other financial institutions to GDP, which is the traditional indicator for financial development is used to proxy for credit constraint, as a more developed financial market should have easier access to financial market. The indicator to measure democracy is Civil Liberties from the Freedom House (also known as the Gastil index), which is widely used in political literature to measure democracy (e.g. Barro, 1999; Acemoglu et al, 2013). According to Gastil (1986-87, p.7), Civil liberties are rights to free expression, to organize or demonstrate, as well as rights to a degree of autonomy such as is provided by freedom of religion, education, travel, and other personal rights. It ranges from 1 to 7, with 1 representing the most civil liberties and 7 the fewest⁵¹.

Table 4.1 gives the summary statistics of the key variables. We could see that there are substantial variations across 90 countries for each variable. Table 4.8 in the Appendix provides a detailed description of more data including source and definition.

⁵⁰ The average public spending on education 1960-1985 is used to proxy for 1960-1990 average considering that the data is quite stable over time.

⁵¹ Another widely used indicator to measure democracy is also from the Freedom House, which is the political rights. The indicator for civil liberties is extremely highly correlated with that for political rights. In the appendix, by replacing the civil liberties by the political rights in the regressions, the results in Table 4.11 confirm that the significance of interaction between democracy and inequality is robust to other measures of democracy.

Table 4.1: Summary Statistics

Variable	Observation	Mean	Std. Dev.	Min	Max
Educational Gini	90	0.61	0.25	0.10	0.99
Fertility rate	90	4.98	1.88	1.89	8.21
Public spending on education	90	0.04	0.01	0.01	0.07
Average years of schooling	90	6.92	2.77	1.37	12.69

4.4.3 Results

The main results suggest that an increase in initial human capital inequality may increase fertility rate and reduce public spending on education. Given that higher fertility rate and lower public spending on education are both found to be negatively related to human capital accumulation, fertility and public spending on education are two channels linking human capital inequality and human capital accumulation.

Table 4.2 shows the regression results of Equation (1), which assesses the link between human capital inequality and fertility rate. To make sure that the coefficient of human capital inequality is not biased by omitted variables, various variables are controlled for, which are suggested in the literature might influence fertility rate. The coefficient of inequality is positive as expected, and more importantly, is strongly significant in each specification. It suggests that higher initial human capital inequality predicts higher fertility rate. In quantitative terms, it is estimated that a one standard deviation (0.25) increase in inequality would have raised fertility rate by at least 0.6 points, which is a strong effect. For example, if Turkey had reduced inequality in 1960 from 0.75 to the level of the US 0.26, the number of children per women in Turkey would have decreased by 1.2.

The last two columns show the results in rich and poor countries separately. The two groups are defined over the income classification of the World Bank, where the countries classified as High Income and Upper Middle Income are in the Rich Group and the ones as Low and Lower Middle in Poor Group. The results support the argument in Perroti (1996) that the link is more significant in more developed countries.

Table 4.2: Effect of human capital inequality on fertility with different sets of controls

VARIABLES	(1) Full	(2) Full	(3) Full	(4) Full	(5) Full	(6) Rich	(7) Poor
Inequality	5.613*** (0.000)	4.470*** (0.000)	3.505*** (0.000)	3.691*** (0.000)	2.504*** (0.002)	2.398** (0.049)	0.487 (0.672)
Income		-0.433* (0.073)	-0.276 (0.268)	-0.055 (0.844)	-0.141 (0.574)	-0.223 (0.390)	0.894** (0.028)
Education		-0.130 (0.448)	-0.144 (0.373)	-0.000 (0.999)	0.111 (0.464)	0.279* (0.062)	-0.245 (0.710)
Mortality			0.006 (0.114)	0.005 (0.164)	0.004 (0.273)	-0.000 (0.974)	0.005 (0.151)
Urbanization				-1.692** (0.012)	-1.778*** (0.004)	-1.239** (0.041)	-3.437* (0.062)
Muslims					1.598*** (0.000)	3.082*** (0.003)	1.150** (0.017)
Catholic					0.005 (0.339)	0.005 (0.361)	0.022*** (0.002)
Protestant					0.003 (0.496)	0.007 (0.244)	0.000 (0.967)
Latin American	0.926*** (0.000)	0.670** (0.012)	0.624** (0.017)	0.625** (0.012)	1.061*** (0.001)	1.667*** (0.000)	-1.605*** (0.005)
Asian	0.011 (0.973)	-0.353 (0.336)	-0.227 (0.533)	-0.297 (0.410)	0.071 (0.848)	0.148 (0.674)	-0.723 (0.284)
African	1.083*** (0.001)	0.610 (0.108)	0.759* (0.052)	0.550 (0.170)	1.071*** (0.005)	1.362* (0.091)	0.314 (0.487)
Constant	1.015*** (0.000)	5.359** (0.013)	4.087* (0.065)	2.996 (0.200)	3.543* (0.078)	3.442 (0.117)	-1.084 (0.718)
Observations	90	90	90	90	90	47	43
R-squared	0.772	0.794	0.800	0.812	0.844	0.865	0.651

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Average fertility rate 1960-1990

Table 4.3 shows the results of Equation (2), which tests the link between human capital inequality and public spending on education. The negative and significant coefficient of inequality implies that countries with more initial inequality tend to invest less in public spending on education in the coming period. There is a concern of reverse causality issue in Equation (2) as public spending on education may be able to affect human capital inequality. In that case, the initial human capital inequality may be linked to initial public spending on education, which is correlated with the dependent variable, i.e. future public spending on education. To ease the concern, Column (9) has controlled for the initial public spending on education. The result shows that the coefficient of initial human capital accumulation remains significant and negative. The last column shows that democracy is a positive predictor of public

spending on education as expected and the positive and significant interaction term shows how democracy and inequality interacts on their impact on public spending on education. The result confirms the argument in the last section that in more democratic countries the negative link between human capital inequality and public spending on education is stronger. In particular, a one standard deviation increase in education inequality would have lowered public spending on education by around 0.5% in a country with the median level of democracy and the effect is larger in more democratic one. Given that the mean of public spending on education about 4.0%, the effect is strong and significant.

Table 4.4 shows how fertility rate and public spending on education relate to human capital level. Column (1) tests the direct effect of inequality by excluding the channel variables. It confirms that human capital inequality has a significant and negative impact on human capital accumulation. The next two columns add to fertility rate and public spending on education separately. We find out that as expected the magnitude of coefficient of inequality drops, while the significance remains. At the same time, fertility has negative coefficient and public spending on education positive as expected, although the coefficient of fertility is insignificant. When the two are included at the same time as shown in Column (4), they are both significant. As discussed in the last section, the effect of fertility on human capital accumulation should be reinforced in countries with more constrained credit market. The last column confirms the hypothesis with a positive and significant interaction term. Reassuringly, the coefficients of fertility and public spending on education are both significant with expected signs. The effect is strong economically. A one standard deviation increase in fertility rate (1.88) in a country with average level of financial development would lead to average years of schooling decrease by 0.2. The effect would be alleviated in a more financially developed country. A one standard deviation increase in public spending on education (0.01) would increase average years of schooling by 0.5.

Table 4.3: Effect of human capital inequality on public spending on education with different sets of controls

VARIABLES	(1) PSE	(2) PSE	(3) PSE	(4) PSE	(5) PSE	(6) PSE	(7) PSE	(8) PSE	(9) PSE	(10) PSE
Inequality	-0.026*** (0.000)	-0.025*** (0.001)	-0.021*** (0.002)	-0.016** (0.044)	-0.016** (0.049)	-0.022** (0.011)	-0.024*** (0.005)	-0.027*** (0.001)	-0.021*** (0.005)	-0.052*** (0.000)
Income		0.001 (0.712)	-0.000 (0.911)	0.001 (0.643)	0.002 (0.569)	0.003 (0.358)	0.002 (0.491)	0.002 (0.533)	0.001 (0.772)	-0.000 (0.970)
Education			0.003 (0.432)	0.003 (0.478)	0.003 (0.461)	0.003 (0.420)	0.002 (0.662)	0.001 (0.778)	0.000 (0.978)	-0.001 (0.645)
Growth				0.120 (0.147)	0.125 (0.141)	0.124 (0.147)	0.131* (0.068)	0.145** (0.012)	0.087 (0.110)	0.117** (0.026)
Urbanization					-0.003 (0.708)	0.000 (0.960)	0.004 (0.542)	0.004 (0.595)	0.005 (0.399)	0.011 (0.140)
Young Population						0.059** (0.034)	0.054** (0.043)	0.038 (0.131)	0.022 (0.260)	0.046** (0.034)
Population Density							-0.002*** (0.009)	-0.002** (0.020)	-0.001 (0.114)	-0.001* (0.080)
Catholic								-0.000*** (0.002)	-0.000*** (0.009)	-0.000*** (0.004)
Initial Public Spending on Education									0.377*** (0.010)	0.329*** (0.006)**
Democracy										0.009*** (0.023)
Inequality* Democracy										0.010 (0.010)
Latin American	-0.017*** (0.000)	-0.016*** (0.000)	-0.016*** (0.000)	-0.013*** (0.000)	-0.013*** (0.000)	-0.018*** (0.000)	-0.019*** (0.000)	-0.010** (0.011)	-0.007** (0.026)	-0.005* (0.090)
Asian	-0.015*** (0.000)	-0.014*** (0.001)	-0.015*** (0.002)	-0.015*** (0.003)	-0.015*** (0.003)	-0.016*** (0.000)	-0.015*** (0.001)	-0.016*** (0.001)	-0.010** (0.012)	-0.009** (0.022)
African	-0.003 (0.398)	-0.002 (0.610)	-0.002 (0.571)	0.001 (0.894)	0.000 (0.926)	-0.000 (0.923)	-0.002 (0.635)	-0.000 (0.923)	0.002 (0.681)	0.002 (0.555)
Constant	0.061*** (0.000)	0.054** (0.011)	0.059** (0.018)	0.038 (0.176)	0.035 (0.230)	0.008 (0.803)	0.016 (0.577)	0.028 (0.386)	0.024 (0.352)	0.038 (0.118)
Observations	90	90	90	90	90	90	90	90	90	90
R-squared	0.420	0.421	0.430	0.442	0.443	0.478	0.510	0.566	0.696	0.727

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Average public spending on education 1960-1990

Table 4.4: Human capital accumulation

VARIABLES	(1) Inequality	(2) Fertility	(3) Public Spending on Education	(4) BOTH	(5) Financial Development
Inequality	-6.645*** (0.000)	-5.765*** (0.000)	-5.692*** (0.000)	-4.426*** (0.001)	-4.169*** (0.001)
Fertility		-0.209 (0.209)		-0.280* (0.084)	-0.417** (0.021)
Public Spending on Education			37.306*** (0.005)	40.777*** (0.003)	35.236*** (0.008)
Financial Development					-1.049 (0.261)
Fertility * Financial Development					0.614*** (0.002)
Growth	11.081 (0.305)	9.565 (0.401)	6.798 (0.497)	4.372 (0.675)	1.229 (0.907)
Muslims	-1.786** (0.025)	-1.486* (0.074)	-1.881*** (0.005)	-1.488** (0.034)	-1.578** (0.027)
Catholic	-0.011 (0.116)	-0.010 (0.164)	-0.006 (0.292)	-0.005 (0.436)	-0.004 (0.526)
Protestant	-0.003 (0.723)	-0.003 (0.789)	-0.007 (0.335)	-0.007 (0.381)	-0.003 (0.665)
Latin American	-1.003** (0.019)	-0.742* (0.079)	-0.762* (0.084)	-0.390 (0.390)	-0.371 (0.411)
Asian	-0.803* (0.087)	-0.704 (0.151)	-0.217 (0.621)	-0.029 (0.950)	-0.209 (0.596)
African	-2.138*** (0.000)	-1.815*** (0.003)	-2.102*** (0.000)	-1.667*** (0.006)	-1.325*** (0.008)
Constant	12.640*** (0.000)	12.892*** (0.000)	10.455*** (0.000)	10.589*** (0.000)	10.652*** (0.000)
Observations	90	90	90	90	90
R-squared	0.809	0.813	0.826	0.833	0.857

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: average human capital investment 1990-2010

As mentioned before, we will use the SUR estimation to see if the results still hold. Table 4.5 provides the coefficients of key variables by applying the SUR. To save space, the coefficients of the other controls are not shown, but the full set of controls used in Table 4.2, Table 4.3 and Table 4.4 are included in the regression. As we compare the results of Table 4.5 to the previous three tables, we could see that all of the key variables remain strongly significant and more importantly, the magnitudes are also quite similar to the OLS results.

Table 4.5: SUR regression

VARIABLES	(1) Fertility channel	(2) Public Spending on Education channel	(3) Human capital
Public spending on education			42.347*** (0.000)
Human capital inequality	2.254*** (0.004)	-0.058*** (0.000)	-3.355*** (0.001)
Human capital inequality* Democracy		0.011*** (0.001)	
Democracy		-0.009*** (0.000)	
Fertility			-0.563*** (0.001)
Fertility* Financial development			0.613*** (0.004)
Financial development			-1.108 (0.226)
Constant	3.728** (0.020)	0.047* (0.054)	10.355*** (0.000)
Observations	90	90	90
R-squared	0.843	0.638	0.854

Pval in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

4.5 Robustness checks

4.5.1 Effect on fertility of different income groups

The impact of human capital inequality on fertility rate was tested through the regressions on two income groups, which was based on the classification of income from the World Bank. The High and Upper Middle Income countries were grouped as the rich group, while the Lower Middle and Low Income countries were groups as the poor group. To make sure that the results are robust, we may check if the results are driven by the particular income classification method. Another straightforward way to divide the sample countries according to the income level is to find the median income of the initial year and define the countries with income above as rich and below as poor. The subsample results shown in Column 2 and 3 of Table 4.6 are consistent with the previous finding in Table 4.2 that the fertility channel is significant in rich countries.

Another way to check the robustness is to introduce an interaction term between human capital inequality and income level in the full sample regression, instead of running the

regression on two groups. Column 1 of Table 4.6 shows that the interaction term is positive and strongly significant, which supports the nonlinearity hypothesis that the impact of inequality on fertility depends on the income level. From the estimated coefficients, we could see that the impact of inequality on fertility will be positive when the log income is over 5.74. Although all the countries in the sample are over the threshold, the income of many poor countries are very close to the threshold. It again confirms that in the poor countries, the effect is small and insignificant.

Table 4.6: Robustness check for fertility channel

VARIABLES	(1)	(2)	(3)	(4)
	Inequality* Income	Median		Drop 10% percentile
		Above Median	Below Median	
Inequality	-6.816* (0.100)	3.053** (0.022)	0.467 (0.681)	2.484*** (0.003)
Inequality*Income	1.188** (0.022)			
Income	-0.878** (0.013)	-0.166 (0.498)	0.876** (0.018)	-0.469* (0.055)
Education	0.233 (0.131)	0.325** (0.047)	-0.515 (0.334)	0.162 (0.605)
Mortality	0.005 (0.118)	-0.004 (0.566)	0.006** (0.031)	0.002 (0.553)
Urbanization	-1.796*** (0.001)	-1.339* (0.087)	-4.545*** (0.002)	-1.816*** (0.006)
Muslims	1.625*** (0.000)	3.694*** (0.001)	1.176*** (0.006)	1.453*** (0.006)
Catholic	0.006 (0.216)	0.007 (0.251)	0.023*** (0.000)	0.004 (0.448)
Protestant	0.008 (0.134)	0.008 (0.186)	0.002 (0.892)	0.006 (0.399)
Latin American	0.879** (0.011)	1.819*** (0.000)	-1.269** (0.024)	0.902*** (0.006)
Asian	0.053 (0.883)	0.159 (0.672)	-0.485 (0.368)	-0.358 (0.451)
African	1.077*** (0.004)	1.087 (0.231)	0.438 (0.235)	0.685 (0.106)
Constant	9.246*** (0.002)	2.739 (0.165)	-1.127 (0.654)	6.424*** (0.002)
Observations	90	45	45	81
R-squared	0.856	0.864	0.784	0.827

Robust pval in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As the effect is strong and significant in rich countries, we would like to see if the positive and significant coefficient of inequality in the full sample is driven by the extremely rich countries. When the countries of the top 10 percentile were dropped, the coefficient of inequality remains strongly significant and is very close to the size of coefficient of the full sample, as shown in the last column of Table 4.6.

Table 4.7: Income inequality included

VARIABLES	(1)		(2)		(3)		(4)		(5)	
	Fertility channel		Public spending on education channel		With interaction of Democracy	Human capital accumulation		With interaction of Financial development		
			Baseline			Baseline				
Public spending on education						44.268***		38.000***		
Human capital inequality	2.289*** (0.004)		-0.018** (0.045)	-0.063*** (0.000)		(0.001)		(0.005)		
Income inequality	-0.001 (0.919)		-0.000 (0.793)	-0.000 (0.309)		-4.429*** (0.001)		-4.136*** (0.001)		
Democracy			-0.003** (0.032)	-0.014*** (0.000)		0.005 (0.725)		-0.005 (0.741)		
Fertility							-0.290* (0.091)	-0.401** (0.032)		
Human capital inequality*Democracy				0.012*** (0.005)						
Income inequality*Democracy				0.000 (0.186)						
Financial development								-0.950 (0.309)		
Fertility*Financial development								0.565*** (0.007)		
Constant	5.707*** (0.002)		0.037 (0.247)	0.073** (0.014)		10.024*** (0.000)		10.505*** (0.000)		
Observations	87		87	87		87		87		
R-squared	0.859		0.600	0.662		0.844		0.861		

Robust pval in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4.5.2 Income inequality vs human capital inequality

The consensus among the theoretical studies is that inequality in wealth plays an important role in economic development. Unfortunately, to my best knowledge till now a comprehensive and comparable dataset to measure wealth inequality across a large number of countries is still unavailable. It causes most empirical studies to use income inequality to proxy for wealth inequality and makes the traditional literature failed to capture the other dimension of wealth inequality. The paper fills the gap to look at human capital inequality. However, we have to make sure the estimated impact of human capital inequality is not driven by income inequality, given that income inequality and human capital inequality are correlated⁵², and income inequality is also found to affect human capital accumulation in the literature (see Chiu, 1998). To do that, income inequality is included together with human capital inequality in the estimations. The indicator to measure income inequality is net Gini coefficient from Standardized World Income Inequality Database (SWIID).

Table 4.7 shows that the coefficients of interest in the baseline results are not affected, which implies that the baseline results may not be driven by income inequality⁵³. In particular, the inclusion of income inequality does not have any impact on the significance of the key variables, and the income inequality is insignificant. The results also confirms the findings of Castello and Domenech (2002) that the human capital inequality measures provide more robust results than income inequality measures in the estimation of standard growth and investment equations. However, given that human capital inequality is not a perfect proxy for wealth inequality, there still might be omitted variable bias. Therefore we should be cautious interpreting the results.

4.6 Conclusion

This paper contributes to the inequality literature focusing on human capital inequality and the main findings are as follows. First, it confirms that human capital inequality has a robust and negative link with human capital level. Second, it investigates the channels through which inequality works on human capital. Two channels are assessed, fertility and public spending on education channel. The former predicts a positive link between inequality and fertility rate,

⁵² The correlation between human capital inequality and income inequality is 0.38 at 1% significance level.

⁵³ Table 4.7 drops the control variables to keep the table short and concise.

which is then negatively related to human capital level. Although it is not the first time that this channel is proposed in the literature, we find out that the link between inequality and human capital is stronger in more developed countries. Moreover, credit constraint is found to play an important role in the negative link between fertility and human capital accumulation. In countries with more credit constraint, the negative impact of fertility on human capital accumulation will be reinforced. Another contribution of the paper is to explain the negative link between human capital inequality and human capital level through the new mechanism, which is public spending on education. In particular, a higher human capital inequality will predict a smaller public spending on education, which would impede human capital accumulation.

Appendix to Chapter 4

Table 4.8: Data Source and Definition

Variable	Definition	Source
Human capital stock	Average years of schooling of the population above 15 years of age	Barro and Lee(2013)
Public Spending on Education	Ratio of recurring nominal government expenditure on education to nominal GDP	Barro and Lee (1994)
Human capital inequality	Gini index of educational attainment	Wail Benaabdelaali et al. (2012)
Income inequality	Gini index of net income	Standardized World Income Inequality Database (SWIID)
Fertility	The total births per woman	World Bank World Development Indicators
Democracy	Civil Liberties	Freedom House
Income	Real GDP per capita	Maddison (2013)
Financial Development	Private credit by deposit money banks and other financial institutions to GDP	Financial Development and Structure Database
Mortality	Mortality rate of infant (per 1,000 live births)	World Bank World Development Indicators
Urbanization	Urban population (% of total)	World Bank World Development Indicators
Population Density	People per sq. km of land area	World Bank World Development Indicators
Young Population	Population ages under 15 (% of total)	World Bank World Development Indicators
Education	Average years of secondary school of ages over 15	Barro and Lee (2013)

Table 4.9: Different time periods: 1960-1985 & 1985-2010

VARIABLES	(1)	(2)	(3)	(4)	(5)
	Fertility channel			Public spending on education channel	Human capital accumulation
	Fertility	Rich	Poor		
Fertility					-0.349** (0.043)
Public spending on education					33.072** (0.011)
Inequality	2.570*** (0.003)	2.466* (0.056)	0.377 (0.740)	-0.062*** (0.000)	-4.576*** (0.000)
Democracy				-0.009*** (0.004)	
Inequality*Democracy				0.011*** (0.009)	
Financial Development					-0.795 (0.409)
Fertility* Financial Development					0.545*** (0.008)
Income	-0.125 (0.662)	-0.212 (0.493)	0.862** (0.030)	-0.000 (0.857)	
Education	0.058 (0.720)	0.261* (0.099)	-0.296 (0.663)	-0.001 (0.684)	
Growth				0.134** (0.012)	4.998 (0.561)
Urbanization	-1.784*** (0.008)	-1.268* (0.058)	-3.032* (0.085)	0.014 (0.102)	
Young Population				0.073*** (0.007)	
Population Density				-0.002*** (0.006)	
Mortality	0.003 (0.384)	0.001 (0.922)	0.004 (0.248)		
Catholic	0.004 (0.449)	0.005 (0.412)	0.020*** (0.005)	-0.000*** (0.000)	-0.003 (0.569)
Muslims	1.595*** (0.001)	3.118*** (0.003)	1.044** (0.030)		-1.471** (0.037)
Protestant	0.002 (0.710)	0.006 (0.311)	-0.000 (0.987)		-0.003 (0.724)
Latin American	1.139*** (0.001)	1.728*** (0.000)	-1.613*** (0.004)	-0.009** (0.012)	-0.291 (0.485)
Asian	0.102 (0.788)	0.200 (0.584)	-0.743 (0.256)	-0.013*** (0.004)	-0.158 (0.695)
African	0.972** (0.012)	1.336* (0.090)	0.180 (0.676)	0.001 (0.839)	-1.244*** (0.010)
Constant	3.695 (0.107)	3.472 (0.180)	-0.396 (0.895)	0.055** (0.032)	10.253*** (0.000)
Observations	90	47	43	90	90
R-squared	0.830	0.862	0.599	0.636	0.863

Robust pval in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4.10: Different time periods: 1960-1980 & 1980-2010

VARIABLES	(1)	(2)	(3)	(4)	(5)
	Fertility channel			Public spending on education channel	Human capital accumulation
	Fertility	Rich	Poor		
Fertility					-0.305* (0.072)
Public spending on education					32.763** (0.010)
Inequality	2.564*** (0.005)	2.458* (0.075)	0.235 (0.833)	-0.052*** (0.000)	-4.921*** (0.000)
Democracy				-0.006** (0.021)	
Inequality*Democracy				0.009** (0.012)	
Financial Development					-0.529 (0.608)
Fertility* Financial Development					0.486** (0.025)
Income	-0.133 (0.674)	-0.240 (0.503)	0.783** (0.044)	-0.001 (0.709)	
Education	0.003 (0.985)	0.247 (0.144)	-0.341 (0.628)	-0.001 (0.619)	
Growth				0.090** (0.037)	2.109 (0.774)
Urbanization	-1.669** (0.023)	-1.185 (0.110)	-2.414 (0.152)	0.012 (0.121)	
Young Population				0.045** (0.039)	
Population Density				-0.001 (0.101)	
Mortality	0.002 (0.543)	0.001 (0.881)	0.003 (0.404)		
Catholic	0.003 (0.538)	0.005 (0.406)	0.019** (0.011)	-0.000*** (0.005)	-0.003 (0.593)
Muslims	1.591*** (0.001)	3.198*** (0.003)	0.905* (0.057)		-1.420** (0.041)
Protestant	0.001 (0.860)	0.007 (0.317)	-0.002 (0.877)		-0.003 (0.699)
Initial public spending on Education				0.331** (0.010)	
Latin American	1.242*** (0.000)	1.819*** (0.000)	-1.572*** (0.004)	-0.006* (0.051)	-0.301 (0.444)
Asian	0.182 (0.645)	0.310 (0.424)	-0.716 (0.252)	-0.009** (0.030)	-0.090 (0.828)
African	0.895** (0.024)	1.335* (0.075)	0.094 (0.821)	0.002 (0.579)	-1.232*** (0.007)
Constant	4.005 (0.114)	3.764 (0.203)	0.569 (0.850)	0.045** (0.047)	10.029*** (0.000)
Observations	90	47	43	90	90
R-squared	0.830	0.862	0.599	0.636	0.863

Robust pval in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4.11: Different measures of democracy

VARIABLES	(1)
Inequality	-0.053*** (0.006)
Democracy	-0.007** (0.026)
Inequality*Democracy	0.009** (0.027)
Income	0.000 (0.918)
Education	0.000 (0.798)
Growth	0.159*** (0.004)
Urbanization	0.011 (0.147)
Young Population	0.065** (0.011)
Population Density	-0.002*** (0.003)
Catholic	-0.000*** (0.001)
Latin American	-0.008** (0.017)
Asian	-0.014*** (0.001)
African	0.000 (0.912)
Constant	0.043* (0.097)
Observations	90
R-squared	0.616

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Chapter 5 Conclusion

The main findings of Chapter 2 are as follows. Firstly, SIZE measure of banking system is found negatively related to economic growth, insignificant in full sample and significant in both subsample results, while bank DEPTH is mostly significantly and positively related to growth. Bank EFFICIENCY is also beneficial to economic growth, but its effect is not significant in full sample. Therefore the results suggest that when assessing the bank-growth link, only looking at the SIZE indicator, which is the common strategy in traditional empirical bank-growth literature, is a potential problem. It overstressed the importance of one aspect of banking development by neglecting others, which are empirically proved to be at least as important as SIZE measure. Secondly, the growth effect of bank development is larger in more corrupt countries. Within less corrupt countries, smaller SIZE of bank system and more corruption will be beneficial to growth and the two are complements in promoting growth. Within more corrupt countries, corruption has no direct effect on growth, but works through the bank-growth channel. More specifically, the adverse effect of increasing SIZE measure of banking system and the positive effects of increasing bank DEPTH and EFFICIENCY will diminish if corruption control is improved.

Drawing on Putterman and Weil (2010), Chapter 3 uses heterogeneity in early development as instruments for income inequality to reassess the impact of inequality on current income. The paper shows the validity of the new instruments statistically and intuitively. The 2SLS estimation shows that inequality is positively related to current income for the full sample, which is in contrast with the results of Easterly (2007), who used another instrument which I have argued is problematic. When I divide the full sample into two subsamples according to the income level, the positive link between inequality and income remains for the poor countries, while the link is negative and mostly insignificant in rich countries. In addition, various hypotheses are tests to explain how inequality impacts income. The results support the redistributive median-voter channel by confirming the negative link between inequality and income in democratic countries.

Chapter 4 firstly confirms that human capital inequality has a robust and negative link with human capital level. Second, it investigates the channels through which inequality works on human capital. Two channels are assessed, fertility and public spending on education channel.

The former predicts a positive link between inequality and fertility rate, which is then negatively related to human capital level. Although it is not the first time that this channel is proposed in the literature, we find out that the link between inequality and human capital is stronger in more developed countries. Moreover, credit constraint is found to play an important role in the negative link between fertility and human capital accumulation. In countries with more credit constraint, the negative impact of fertility on human capital accumulation will be reinforced. Another contribution of the paper is to explore a new channel, which is public spending, to explain the negative link between human capital inequality and human capital level. The results suggest that a higher human capital inequality will predict a smaller public spending on education, which would impede human capital accumulation.

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