THREE ESSAYS ON INCOME INEQUALITY

A thesis submitted for the degree of Doctor of Philosophy

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ERRATA

Page 20, line 5: “were” for “was”
Page 29, line 4: “caution” for “cautions”
Page 32, Table 2.3: “Dep. Var.” for “D.V.”
Page 34, Table 2.4: “Dep. Var.” for “D.V.”
Page 34, Table 2.A2: “Trade openness” for “pwt_openk3”
Page 48: Font change issues are addressed
Page 63, line 5: “columns” for “column”
Page 63, line 12: “instruments” for “instrumnts”
Page 63, line 17: “instrumented” for “instrmented”
Page 66, line 12: “increase” for “inccrease”
Page 66, line 13: “have” for “has”
Page 71, line13: “progressive” for “progrssive”
Page 71, line 17: “progressive” for “prograssive”
Page 83, line 14: “general method of moments” for “general method of momentum”
Page 83, line 5: “Table 4.2” for “Table 2”
Page 84 para 1, last sentence: “Chudik and Pesaran (2013)” for “Pesaran and Chudik (2014)”
Page 89 para 2, last sentence: “bias-corrected least square dummy variables” for “corrected least square dummy variables”
Page 94, footnote 32: “Maddison” for “Madison” and “1820-2010” for “0-2010”

ADDENDUM

Page 20, line 12: add ‘the’ after “On the other hand,”
Page 21, line 1: add “to” after “and force them”
Page 28, line 12: add “are” after “as they”
Page 29, Table 2.1: Add at the end of notes: “Other religions refer to all the other religions except Muslims, Protestants and Catholics”
Page 42: Add the following reference in the reference list of chapter 2:
UNU-WIDER (2008). UNU-WIDER World Income Inequality Database, Version 2.0c, May 2008.

Note: Additional addendum at the end of the dissertation

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Abstract

This thesis contains three essays on income inequality. The underlying theme is to investigate the relationship of income inequality with political instability, economic growth, and financial development. To this end, the first study aims to explore the relationship of income inequality with political instability. Motivated by the observation that politically unstable countries tend to have wide income gaps, the study explores the possibility that major source of political instability is income inequality, which can be traced back to the history of early development across the globe. Using data for 95 countries, the estimates provide support for the notion that before 1500 CE early development of our ancestors, and after 1500 CE colonization, and evolution of institutions can explain today's income inequality, which subsequently affects political stability of a country. Irrespective of the subsamples used, the results confirm highly significant impact of unequal income distribution on political instability.

The second study investigates the endogeneity between income inequality and economic growth, which seems to be impregnable in the literature. Motivated by Spolaore and Wacziarg's (2009) influential idea that genetic distance of population between countries put barrier to the diffusion of development, this work constructs weighted average growth of other countries as instruments for economic growth that can explain inequality across the countries. The weights come from genetic and geographic distances between two countries. Income growth per capita is instrumented to find growth's impact on the top income shares first, and then the residuals of the regression are used as instruments for the top income shares to identify the net impact of top income shares on economic growth in the subsequent regressions. Using top income data of fourteen OECD countries for around hundred years,

the estimates provide support to the view that growth reduces top income shares; however, top income shares in turn enhances economic growth.

The third study explores the possibility of financial development as a major determinant of top income shares in the OECD countries. In a century long panel of time series data of top income shares and financial development, the work attempts to capture the impact of financial development on the income distribution of the top income strata. Couple of dynamic models has been used to check the robustness of our hypothesis in favour of financial development as a major source of rise in the top income shares. The results show that a one standard deviation rise in financial development, measured by private credit-GDP ratio, is associated with an increase of the top 1% income shares by around 0.3 standard deviation of its own. The effects are also robust to the other measures of top income shares.

Declaration of Authorship

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the dissertation.

[redacted]

(Anjan Kumar Saha)

This thesis is dedicated to the memory of my parents

Aloka Rani Saha & Brojo Gopal Saha

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Chapter 1: Introduction

1.1 Introduction

Income inequality is central in the discussion of the United Nations post-2015 sustainable development agenda, which focuses on the inequality of not only the developing and least developed countries, but also of the developed ones. A poor citizen in a highly developed country is none better off than her counterpart in a developing country, as both are struggling for the same basic subsistence. Inequality is also in the centre table of discussion in the recent days after the publication of Thomas Piketty's (2014) book "Capital in the Twenty-First Century", which anticipates a dreadful future of income distribution within the countries, especially in the developed ones, due to the dwindling rates of economic growth against relatively higher return to capital. Using top income data, Piketty (2014) argues that if the growth rates of the economies cannot be increased to the level of the return to capital, wealth will accumulate in the hands of a few rich, who are mainly the owners of capital.

The questions ultimately arise: what are the factors that determine income gaps in the societies? Or what are the influences that support the persistence of income inequality? And how economic and financial developments contribute to income distribution? Three separate chapters of this thesis investigate these questions. The second chapter examines the deep rooted historic factors that contribute to income inequality as well as political instability, and the subsequent two chapters find the impact of economic growth and financial development on income inequality.

The second chapter investigates the deep roots of income inequality to find if there is any connection between income inequality and long term historical factors that covers from the exodus of Homo sapiens from the cradle of humankind in Addis Ababa around 70,000 years ago to the recent colonization and mass migration after 1500 CE. In fact, many economists recently shifted their focus from the proximate determinants to the deeper and fundamental reasons to clarify if there is any possibility that various pre-historic and historic stages of development and shocks such as discoveries of technologies, colonization, etc. triggered income inequality. They investigate if there is any impact on the distribution of income across the countries today due to the human capital and other experiences our ancestors gathered for tens of thousands of years. They also examine the redistribution of agricultural endowments and other natural resources among the populations through wars, colonization and mass migration, especially since the inception of the Columbian era (after 1492 CE), and whether the redistribution still reproduces income inequality in today's world.

Homo sapiens started departing from Addis Ababa around 70,000 years ago (Diamond 1997; Putterman 2008; Comin *et al.* 2010; Ashraf & Galor 2013). Around 10,000 years ago, Neolithic revolution was kicked off and they continued to settle at various parts of the world. The settlement is associated with the shift from the nomadic life to agriculture, which is a remarkable event in the human history. The adoption of agriculture and subsequent development of various technologies advanced human-kind to use improve modes of production gradually. For the last two to five thousand years, they got the taste of the formation of the political states. The historical development literature argues that these events have enormous influence on today's income distribution across the countries. It also argues that genetic diversity that formed due to the departure of population from human's place of origin and subsequent exposure to various bio-geographical environment for long also have influence on today's income inequality (Putterman & Weil 2010; Ashraf & Galor 2013).

While history is important to figure out how past matters in shaping current income distributions, it is also important to investigate the contribution of the proximate factors such as economic and financial development in today's income distribution. On the other hand, income distribution itself may also have some influence on current socio-economic development and stability of the country. This thesis therefore encompasses the relationship of income inequality with a few key economic variables: (1) political instability, (2) economic development and (3) financial development across the countries. The relationship of income inequality with all the three variables are much debated in economics and other social science literatures, but still each of the relationships is a puzzle. This is mainly because of extremely high endogeneity between income inequality and any of these variables. The thesis therefore aims to disentangle each of the puzzles separately, and contribute to the development economics literature by trying out a few innovative ways to solve the endogeneity that exists between income inequality and any of the above mentioned three variables. It aims to offer causal interpretation of the relationships, which are extremely important in policy decisions regarding income redistribution, political stability, and overall economic growth.

The thesis consists of three self-contained essays that are written in journal paper format in the subsequent chapters. The first essay revisits the relationship between income inequality and political instability tracing back to their relationship in the history of early allocation of agricultural endowments in the period of colonization and mass migration (Engerman & Sokoloff 1997). It also seeks to connect current political instability with ancestral background of the current population through income inequality. The study predicts that various long term historical factors contributed to the differences in human capital and knowledge of our ancestors, who lived in various parts of the world before the Columbian era (before 1500 CE), can explain a substantial part of the variation in the current income inequality through the differences in income among the population groups with different ancestral identities (Diamond 1997; Putterman 2008; Comin *et al.* 2010; Ashraf & Galor

2013). Using cross sectional data of 95 countries, the work explores income inequality as a major determinant of political instability.

The second essay revisits the relationship between income inequality and economic growth, which is not clear in the literature. A large body of literature discussed the issue, but ended up with both positive and negative impact of inequality on growth, and growth on inequality. This work re-examines the inequality-growth relationship by using two new instruments for economic growth, based on genetic and geographical distance between countries. The instruments are constructed on the simple idea that growth of one country can spill over to the other countries, but genetic distance, similar to geographical distance, puts barrier to the diffusion of growth. The motivation comes from the influential work of Spolaore and Wacziarg (2009), which argue that genetic distance puts barrier to the diffusion of development. They contend that genetically distant countries have lack of interest to interact each other in trade and other exchanges. On the other hand, genetically similar countries can easily build up relationship among them to exchange their goods, services, technologies, ideas and culture. Based on this notion, we construct weighted average growth of other countries as an instrument for a country's economic growth, where inverse of distance (genetic or geographical) between two countries is used as weight. Using data of fourteen OECD countries in an unbalanced panel of 1900-2009, the work finds growth to reduce top income shares, while top income shares enhances economic growth.

The third essay looks into the relationship between financial development and top income shares in the OECD countries sample. Using top income shares data of around hundred years, the study reveals that financial development enormously benefits the rich in societies. The results are robust across various top income groups. Using number of dynamic models in a long unbalanced panel of fourteen OECD countries, the study explores the possibility that financial development is a major source of rise in the top income shares. The work however does not find any significant effect of technological development and trade openness on top income shares. They seem to work only through the channel of financial development.

This thesis contributes in the literature by addressing few old debates encompassing inequality, instability and development from new perspectives. It exploits deep roots of economic development to connect them with today's income inequality and political instability. The work introduces a number of new instruments to look into the inequality-political instability relationship tracing back to the genetic diversity, migratory distance and technological knowledge of our ancestors, who lived in various parts of the world in the year 1500, but their successors constitute today's population. It also constructs new instruments for economic growth to exploit the endogeneity between economic growth and income inequality. In addition, it explores the impact of financial development on the top income distributions. This thesis extends two ever first exclusive works in the OECD countries' context, which uses top income shares as a measure of inequality in examining the inequality-growth and inequality-financial development relationships.

The works in this thesis are timely as the debate and dispute regarding the relationship between top income shares and the economic development is at the highest. The works will enrich the development economics literature casting new lights on the debates of the inequality-instability, inequality-growth, and inequality-financial development relationship, which demand thorough inquiry due to the recent longstanding recession began in 2007, and the emergence of socio-political instability around the world including Middle East, and Africa.

Three self-contained essays are placed in chapter two, three and four of the thesis. A final chapter puts concluding remarks as well as directives for future research. Although the three essays are quite distinctive in answering different sets of questions, all of them have an implicit impulse to answer how income inequality is shaped by various proximate as well as deep-rooted factors, and how inequality is contributing in shaping current economic and political outcomes across the countries. The impact of economic and financial development on inequality is also examined. In this regard, the thesis has interrelatedness among the chapters. However, being all the three essays are distinct, as it demands, they have their own subsections comprises of introduction, conclusion, and other relevant parts. Consequently, one can easily be able to read a single essay without bothering to read the others on the one hand, and on the other a common flavour can be derived of the entire thesis while reading the general introduction and concluding remarks.

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Chapter 2: Early Development, Income Inequality and Political Instability

Summary: Motivated by the observation that politically unstable countries tend to have wide income gaps, this paper explores the possibility that major source of political instability is income inequality, which can be traced to the history of early development across the globe. Using data for 95 countries, the estimates provide support for the notion that before 1500 CE early development of our ancestors, and after 1500 CE evolution of institutions, and colonization, can explain today's income inequality, which subsequently affects the political stability of a country.

Key words: income inequality; political instability; economic development

JEL Classification: O10; O40; D31; O57

2.1 Introduction

Political stability is central to the development paradigm of a country. Nations that lack a stable polity often end up in failure, with devastating consequences for long-term growth. One potential source of political instability is economic inequality. Politically fragile countries plagued by frequent occurrences of violence, internal unrests, assassinations, mass killings and war are often associated with severe income inequality. Fragile states, such as the Central African Republic, Uganda, Guinea, and Zambia, are also among the countries that have the highest levels of income inequality as measured by the Gini index. This observation begs the question of whether inequality and political instability are closely related.

Alesina and Perotti (1996) argue that in a society with a highly polarized distribution of resources, the impoverished group with negligible resources and incomes will have strong incentives to demand radical changes of income distribution, which will increase the likelihood of political movements, revolts, violent protests, and illegal seizures of power. Hence, social discontent fuelled by persistent inequality will tend to generate various types of socio-political turmoils that ultimately jeopardize the stability of a political regime. Using data for 71 countries over the period 1960-85, their empirical evidence suggests that political instability reduces investment and retards economic growth through creating an insecure socio-political climate.

The relationship between inequality and political instability is formalized in the work of Acemoglu and Robinson (2001). They propose that in a highly unequal society, the rich will tend to suppress democracy in order to prevent the redistribution of wealth. Hence, in the presence of opposite interests held by two economically divergent groups, neither a democratic nor an autocratic regime can stabilize the country. A shift to democracy will induce the elites to capture power in order to establish an autocratic regime that does not promote redistribution. On the other hand, the poor may demonstrate against a dictatorial regime and try to snatch power from the rich in order to obtain a more even distribution of economic resources. Consequently, a highly unequal country may oscillate between democracy and autocracy, thus triggering instability that destabilizes the economy.

In estimating the effect of income inequality on political instability, it is important to allow for the possibility of a feedback effect. In principle, political demonstrations initiated by the poor in a highly unequal society can be supressed by the rich who face the risk of losing their wealth. Given that the elites have sufficient socio-economic and political power to hold down the unrest, this may strengthen the position of the rich and further widen the income gap. On the other hand, to curb political demonstrations, regime in power may redistribute wealth in favour of the influential groups (Acemoglu *et al.* 2004). Higher political instability could also worsen the income distribution through generating higher inflation and lower productivity (Aisen & Veiga 2013).

In light of the above, we use couple of instruments to isolate the endogenous component of income inequality and test how the exogenous variation in income inequality influences political instability. Specifically, the underlying premise of this approach is that variation in geographical and bio-geographical factors, and long term historical factors are root causes that generate the gap between the rich and the poor. In this regard, this work is related to a strand of literature that discovers the deep roots of current unequal distribution of income across the countries (Diamond 1997; Olsson & Hibbs Jr 2005; Comin *et al.* 2010; Ashraf & Galor 2013). Some works in the same strand cast light on within country inequalities delving into the roots in the long term history of development (Acemoglu *et al.* 2001; Engerman & Sokoloff 2002; Easterly 2007; Putterman & Weil 2010).

Our aim is to study the role of income inequality as a principal channel through which early distribution of endowments influences current political stability. We regress the political instability in the last decade (2000-2009) on income inequality in the previous decade (1990-1999), and instrument the latter using various geographical and early development indicators. Our first-stage regressions of income inequality on those indicators deliver economically and statistically significant results. The second-stage estimates provide evidence that the exogenous component of the variations in income inequality positively affects political instability. This finding survives in a battery of robustness checks.

Our work is built upon the contribution of Alesina and Perotti (1996), who focus on testing the effect of political instability on investment and growth. It is, in particular, related to Easterly (2007), and Putterman and Weil (2010), who show that income inequality has a strong connection with historical endowments and early development. It is also related to Roe and Siegel (2011), who found income inequality to hinder financial development through its negative impact on political stability. The chapter proceeds as follows. The next section describes the empirical approaches and data. Section 3 describes instruments of income inequality, and section 4 reports the results. The final section concludes.

2.2 Empirical Strategy and Data

2.2.1 Regression model

The following least-square regression model is used to investigate the impact of income inequality on political instability:

$$PI_i = \alpha + \beta Ineq_i + \gamma' CV_i + \varepsilon_i \quad (1)$$

where PI is an index of political instability and $Ineq$ is a measure of income inequality. β is our parameter of interest and its estimated value is expected to be larger than zero. CV refers to a vector of control variables and ε is the error term. The control variables include per capita hydrocarbon reserve, landlockedness, terrain ruggedness, and religions.

Controlling for the effects of religions is important since more homogeneous societies are also likely to be politically more stable whereas fractionalized populations may lead to multiple elite groups competing with each other for power (Alesina & Perotti 1996). We include a measure of resource reserve since natural endowments that are easily appropriable may be a source of conflict when different groups fight to gain control over the resources (Isham *et al.*, 2005).

Finally, controlling for the effect of geography is necessary since they may directly affect economic outcomes (Gallup *et al.* 1999). Landlocked countries, for instance, may lack the opportunities for trade, which is crucial for promoting peace and political stability (Viner 1937). The effect of rugged terrain, however, is less clear-cut. People isolated by rugged terrains lack the ease of demonstrating against the regime due to the high transaction costs of showing up in the big cities to attract the attention of the government and media. The difficulties of transporting goods due to slopes and uneven landscapes also increase the transaction costs of trading. On the other hand, it is equally likely that rugged terrains provide natural protection for the dissent groups to initiate subversive activities not easily detected or suppressed by the government.

2.2.2 Data

We use the *State Fragility Index* (*SFI*) from the Center for Systemic Peace (CSP) as a measure of political instability (PI). It captures fragility associated with security, social, political and economic development. Effectiveness and legitimacy for each of these dimensions are measured. Except for "economic effectiveness", which is measured on a 0-4 scale, all indicators are measured in the range of 0 to 3. SFI is defined as the sum of all these components.

As a robustness check for the results, we also measure political instability using two other indicators. Specifically, the *Failed State Index* (*FSI*) of the Fund for Peace (FFP) is comprised of a total of 12 social, economic and political indicators, including: 1) mounting demographic pressures; 2) massive movement of refugees or internally displaced persons creating complex humanitarian emergencies; 3) legacy of vengeance-seeking group grievances; 4) chronic and sustained human flight; 5) uneven economic development along group lines; 6) sharp and/or severe economic decline; 7) criminalization and/or delegitimization of the state; 8) progressive deterioration of public services; 9) suspension or arbitrary application of the rule of law and widespread violations of human rights; 10) security apparatus operating as a "state within a state"; 11) rise of factionalized elites; and 12) intervention of other states. The ratings for each indicator are placed on a scale of 0 (most stable) to 10 (least stable).

The last measure of political instability is taken from the World Bank Governance Indicators (WBGI) compiled by Kaufmann *et al.* (2010), who give rankings of political stability data for each country. The data provide several measures that capture perceptions of the likelihood that the government in power will be destabilized or overthrown by unconstitutional and/or violent means. Countries are ranked from having the least stable political regime (0) to enjoying the most stable political regime (100). The data are subtracted from 100 to reflect instability of a political regime. We scale all three measures to 0 and 1 and take the average of 2000 to 2009. A larger value of these indices reflects higher political instability.

For income inequality ($Ineq$), we follow the standard practice in the literature by using the Gini coefficient data provided by the UNU-WIDER. Data from the World Development Indicators (WDI) of The World Bank and Solt (2009) are also used to provide a sensitivity check of the results. Solt (2009) improves the comparability of the income inequality estimates from different sources by putting together a dataset that covers the largest possible number of countries and years. The use of this dataset therefore serves as a useful check for our results. All data are averaged over the period 1990-1999 to examine how initial income inequality affects the subsequent development of political instability in the next decade.

Detailed sources of all the data, summary statistics, and correlation among the key variables are presented in the appendix Tables 2.A1, 2.A2, and 2.A3, respectively.

2.2.3 Endogeneity

Endogeneity limits the credibility of ordinary least square (OLS) estimates. It may arise from omitted variable bias, simultaneity, or measurement errors. Omission of a relevant regressor will induce endogeneity bias, and as a result, may provide incorrect estimation of β in Eq. (1). We control for geographic and religion variables that believe to have effect on long term income inequality and political instability.

Measurement errors, on the other hand, are also a major source of endogeneity bias. A regressor may be measured with errors, and consequently OLS estimate may become biased and inconsistent. For example, although widely used, Gini data has criticism in terms of quality and measurement, especially in the cross country analysis. The data in different countries are measured at different points of time with diversified techniques that may reduce the cross country comparability of the data (See Atkinson and Brandolini (2001)). These issues, coupled with the fact that income inequality may be correlated with some unobserved omitted variables, will subject the estimates to endogeneity bias, and hence, we need to carefully interpret the coefficient estimates.

The study uses average of 1990-99 data of income inequality to evaluate its effect on political instability of the next decade. Strategically, it reduces the simultaneity bias by reducing the feedback effect operating from political instability to earlier decade's income inequality.

However, as long as political instability and income inequality are persistent, 2000s political instability can have an impact on 2000s income inequality, which is highly correlated to previous decade's inequality. Therefore, we cannot get rid of the simultaneity that runs from political instability to income inequality. As a result, the least square measure becomes biased and inconsistent although efficient.

Given that $Ineq$ and ε are likely to be correlated, eq. (1) will be estimated using instrumental variable (IV) estimators. Accordingly, the first-stage relationship is specified as follows:

$$Ineq_i = a + b'IV_i + c'CV_i + e_i \tag{2}$$

where IV is our instrumental variable and e is the residual.

We use a linear combination of two or more instruments that helps to identify the model through overidentification tests, as using a single instrument only exactly identify the model. A couple of instruments for income inequality from different time periods of early development strengthens the identification of our benchmark model in eq. (1) by constructing overidentification tests for the validity of our model.

As additional checks, we report a few simple exclusion restriction tests. The main idea is that if an instrument is used as a control variable and it remains insignificant in the second stage least square measurement, then we can conclude that the instrument does not have any direct impact on the dependent variable, but through the other instruments.

2.3 Instruments for income inequality

Our instruments for income inequality come from various historical sources. We gradually exploit deeper roots of inequality in the long term of history. We discover the roots from modern era of colonization and institutionalization (after 1500 CE), and pre-modern era of early development (until 1500 CE). We divide pre-modern era into after 1000 BCE, and before 1000 BCE periods, for the ease of picking instruments from different epochs of time.

2.3.1 Post 1500 channels

Many authors trace today's inequality into colonization and massive migration that occurred in the sixteenth century and onwards. Our post 1500 channels are mainly based on the inequality hypothesis of Engerman and Sokoloff (1997), institution hypothesis of Acemoglu *et al.* (2001), and inequality hypothesis of Putterman and Weil (2010), which provide traces to find instruments for income inequality. The instruments are based on colonization and institution formation in the last five hundred years, and ethnolinguistic fractionalization of the current population that are discussed in the following subsections.

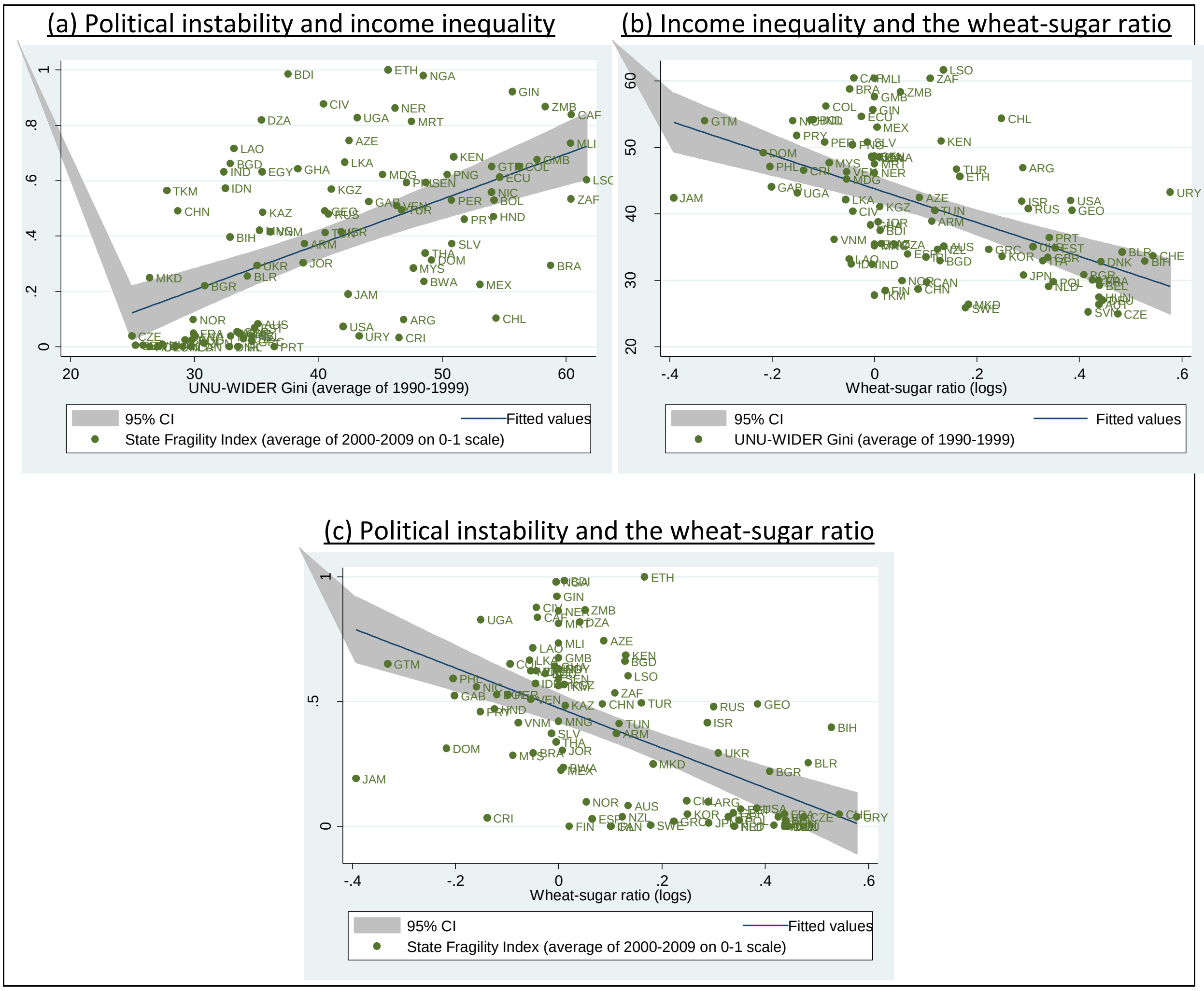
2.3.1.1 Wheat-sugar ratio

One of our identification strategies is based on wheat-sugar ratio (WSR)-a ratio of land area in a country suitable for wheat production relative to sugarcane production that captures the structural inequality[1] embedded in the income inequality of an economy from the early stages of development. This idea originates from Engerman and Sokoloff's hypothesis that in the early stages of colonization, dissimilar features of the colonies' factor endowments divided the Americas and Caribbean into two different types of settlements, which set the paths for their different development trajectories. Latin America and the Caribbean possess fertile land that is mainly suitable for sugarcane production, which requires a large number of workers in order to enjoy economies of scale. On the other hand, land in North America is ideal for growing wheat and other types of crops in small family farms that are less labour intensive. Consequently, a small number of Latin American and Caribbean colonizers, and

[1] Structural inequality refers to the inequality formed in a society through historical events such as colonization, conquest, migration, wars, etc.

local elites became the owners of large croplands. This economy produced an unequal society, which prompted land owners to install extractive institutions through importing slaves and exploiting local peasants.

Figure 2.1 The relationships between political instability, income inequality and the wheat-sugar ratio



In contrast, the Europeans came en masse and formed a strong middle class, owning small farmlands in the US and Canada. These large-scale middle class settlers introduced rules that protected property rights. A more equal distribution of resources led to the creation of supportive institutions, enabling them to achieve today’s prosperity. Hence, the relative proportions of land suitable for wheat and sugarcane cultivation can effectively be used as a natural instrument for income inequality to examine its causal effect on political instability. Until the nineteenth century, only a few countries around the world were left un-colonized, especially by the European colonizers. As a result, WSR can explain current political instability of a country only through its impact on income inequality, not any direct impact on political instability throughout the world.

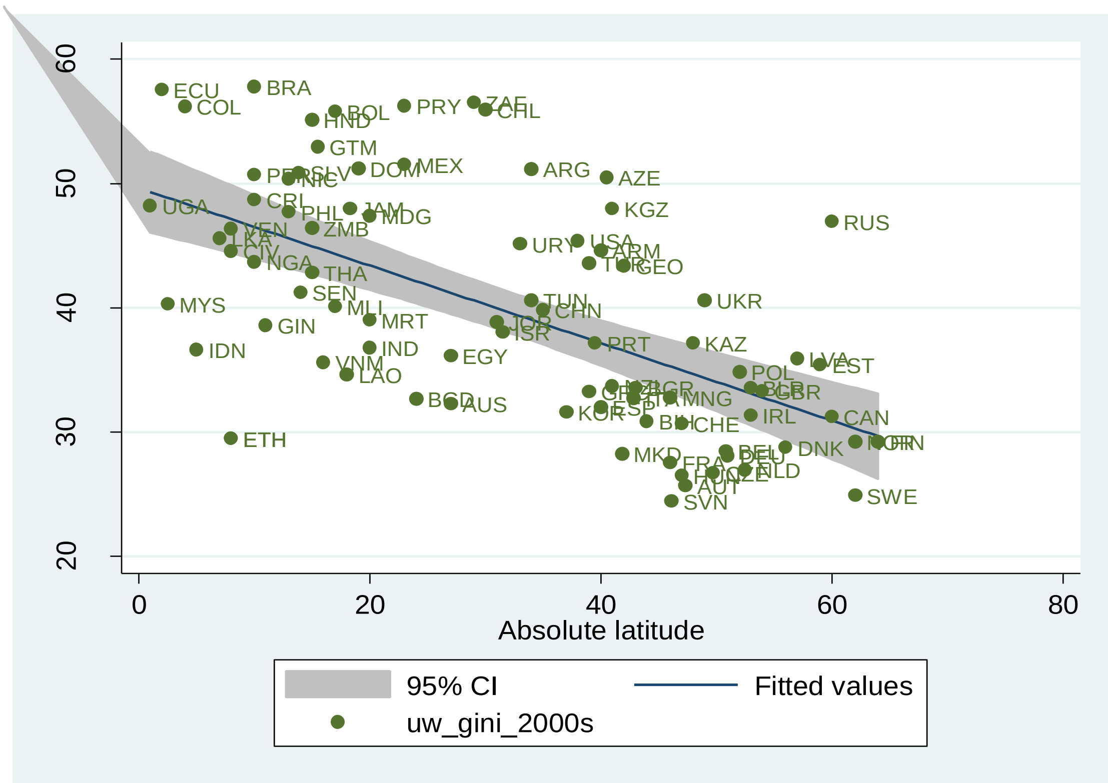
The instrument is measured using the data on the wheat-sugar ratio from Easterly (2007). It refers to the ratio of land suitable for planting wheat relative to growing sugarcane, and is expressed as: $log\left(\frac{1+share\ of\ arable\ land\ suitable\ for\ wheat}{1+share\ of\ arable\ land\ suitable\ for\ sugarcane}\right)$. It captures the degree of equality of the initial stage of agricultural resource distribution, where a higher ratio implies a more even distribution.

Figure 2.1(a) shows the scatter plots for our key measure of income inequality against political instability, measured by state fragility index (*SFI)* of Center for Systemic Peace. It captures fragility associated with social, political and economic development along with security in a 0-25 scale. Consistent with our prediction, the graph shows that state fragility is an increasing function of income inequality. Figure 2.1(b) shows the first-stage relationship between income inequality measured by the UNU-WIDER Gini coefficient and the wheat-sugar ratio. These variables display a strong negative relationship, suggesting that the wheat-sugar ratio is potentially a strong and valid instrument for income inequality. Finally, Figure 2.1(c) shows the reduced-form relationship between *SFI* and the wheat-sugar ratio. This relationship, however, is likely to reflect the influence of the wheat-sugar ratio on political instability through its effect on income inequality.

2.3.1.2 Absolute latitude

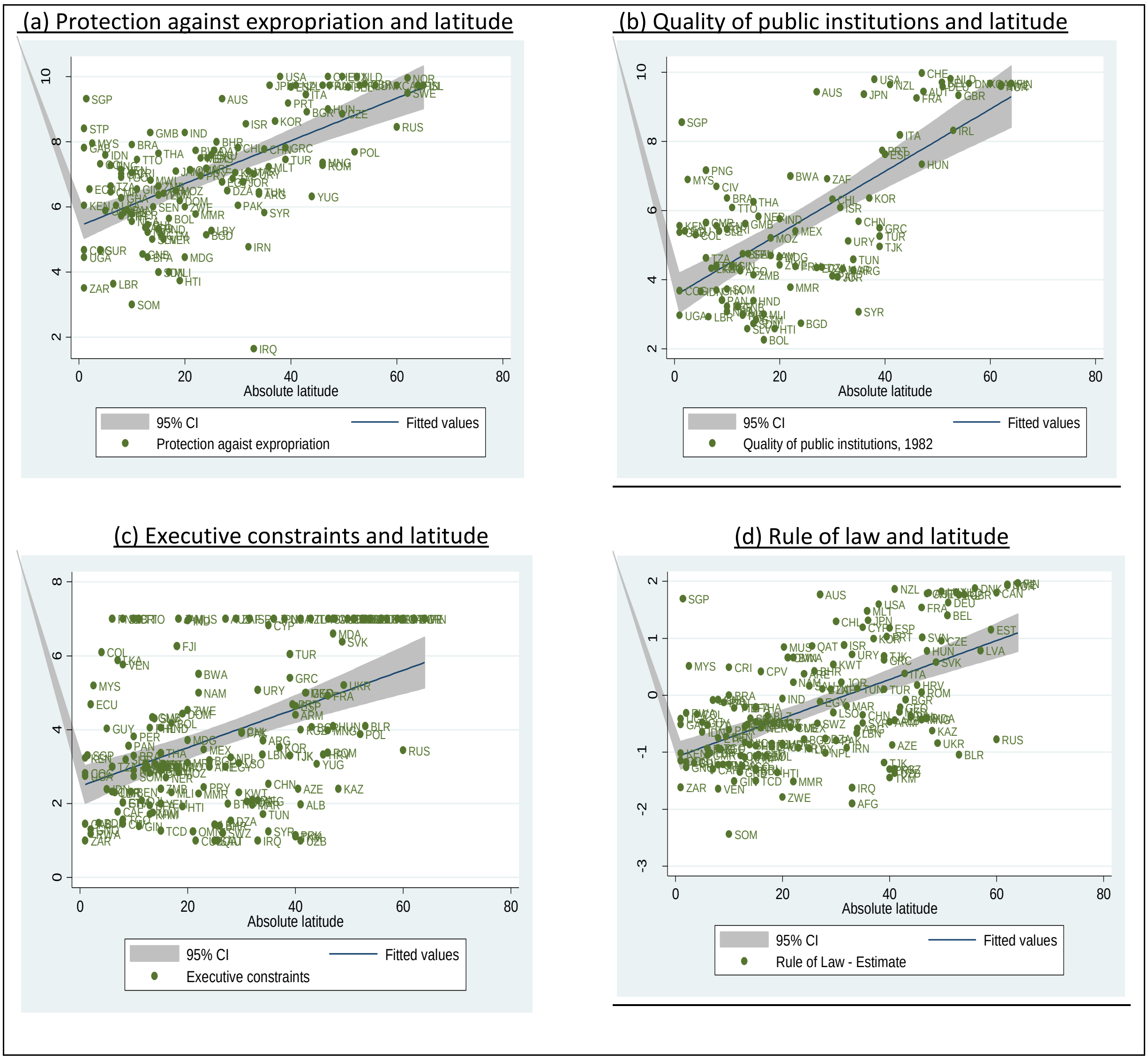
Engerman and Sokoloff (1997) argue that the early endowments in Latin America and the Caribbean tempted colonizers to snatch land from the peasants and force them to work in agricultural estates that required larger economies of scales. As a consequence, the bulk of the population became extremely poor except a few elites, and resulted in a very unequal society. Colonizers set up bad institutions to extract resources, and in order to continue the extraction they maintain an unequal wealth distribution with bad institutions as a means that persist today. In fact inequality and bad institutions feed one another to maintain the status quo of the rich against the poor in Latin American and the Caribbean society.

Figure 2.2 The relationships between income inequality and absolute latitude



In the context of inequality and institutions, the work of Acemoglu *et al.* (2001) is similar to that of Engerman-Sokoloff. They argue that colonizers established extractive strategies where the bio-geographical environment was not favourable for settlement. They emphasize the disease environment that differentiates the institutions between settler colonies and extractive colonies. Diseases such as yellow fever and malaria were rampant in extractive colonies, and while the locals had developed a resistance to those diseases, they were fatal to settlers. Thus colonizers did not move to those areas en masse and did not set up good institutions. Acemoglu *et al.* highlight the persistence of institutions as major determinants of today's prosperity. Countries with good institutions gain higher per capita income, while those with "bad" institutions did not.

Figure 2.3 The relationships between various institution measures and absolute latitude



In the beginning of the twentieth century most of world had gone through colonization by European powers. Colonizers set up institutions that favoured their optimal strategies, either only to extract resources and not to settle, or to settle there. They maintain high inequality in the extractive colonies through the use of extractive institutions. In central

Africa, for example, colonizers set up bad institutions as these places were afflicted by high mortality rate among Europeans, who could not withstand the diseases of the tropics. Except in the settler colonies such as those in the USA, Canada, Australia, and New Zealand, the colonizers set up bad institutions that persist today. As a result, extractive strategies, and hence bad institutions that support widespread inequality was engrained in societies around the world, from central and Latin America, to Africa and Asia. In order to run their extractive machineries, colonizers secured support from a small group of elites, who received rank, wealth, and status from the colonizers. However, the majority of the population were deprived of prosperity and, in most cases, lived a life below subsistence level.

The resulting inequality is a persistent problem in these countries. Chong and Gradstein (2008) find that an earlier decade's income inequality (1981-1985) has a negative impact on the institutional quality of the subsequent decade (1996-2000). On the other hand, earlier decade's institutional quality also has a negative impact on the next decade's income inequality. They frame the inequality-institution relationship in a theoretical model and test it using a sample of 115 countries. Inequality and instability exhibit a reinforcement of one by the other in their work.

We observe that countries with bad institutions and more social inequalities are concentrated near the equator, whereas countries with good institutions and more social equality are farther from the equator. The disease environment that is highlighted in Acemoglu *et al.* (2001) is also related to the latitudinal position of a country on the earth. Countries near the equator are warm, and creating a breeding ground of many deadly diseases including malaria and yellow fever, which discouraged Europeans from settling. The disease environment instead pushed European colonizers to set up bad institutions for extraction of resources. Besides, countries near the equator are endowed with natural and agricultural resources that favoured sugar and other produce on a larger scale than wheat and other small-scale crops. This helped colonizers to take resources from the peasants, and force them work on large estates, thereby establishing an unequal society for the extraction of resources. As a result, the bad institutions and highly unequal societies seem to be concentrated nearer the equator. The good institutions and more equal societies are distributed farther from the equator, where the colonizers originated, or where they set up institutions similar to their own.

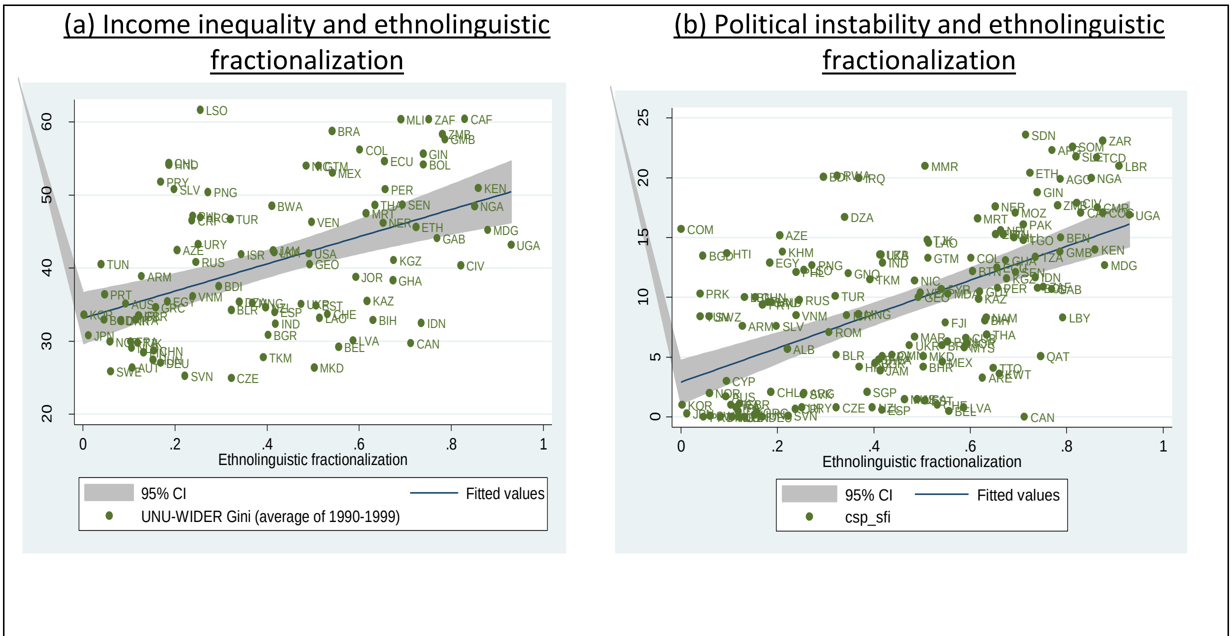
The simple correlation between UNU-WIDER Gini and latitude is shown in Figure 2.2, where lower Gini index is associated with larger values of absolute latitude. Figure 2.3 shows the relationship between latitude and a number of institution variables such as PRS's protection against expropriation, WBGI's rule of law, ICRG's quality of institutions, and Polity IV's constraints on executives' scores. In all the cases, countries farther from equator exhibit better institutions.

Given the facts, latitude seems to serve as an instrument for income inequality to find its relationship with political instability. The exclusion restriction is that there is no direct impact of latitude on political instability except through the channel of income inequality (this was tested, and the results are reported in Table 2.3). Hall and Jones (1999), among others, used latitude as an instrument for various institutional features in their empirical work. We find no inconsistency in using latitude as an instrument for income inequality, as a higher absolute latitude reflects the presence of both good institutions and low inequality simultaneously. Given the obvious exogeneity of absolute latitude, the use of latitude to project income inequality alleviates concerns regarding the potential endogeneity between observed income inequality and political instability. We, therefore, use absolute latitude from La Porta *et al.* (1999) as an instrument for income inequality for the sake of our identification test.

2.3.1.3 Ethnolinguistic fractionalization

Putterman and Weil (2010) argue that variation in the early development of the ancestors of today's population can explain income inequality of a country. They show that populations that have a richer ancestral state history or early agriculture adoption are on the higher rung of the income ladder in a country. Based on the same reasoning, it is also reasonable to argue that the ethnolinguistic fractionalization today within a country can put different ethnolinguistic groups at different levels of income in a society. For instance, in a country one ethnolinguistic group with higher political power can maintain higher income status relative to others. Michalopoulos (2012) documents evidence of this status quo using satellite images of light density at night to verify whether ethnic inequality and income inequality are related.

Figure 2.4 The relationships between political instability, income inequality and ethnolinguistic fractionalization



This work uses ethnolinguistic fractionalization (ELF) as an instrument for inequality that has no direct effect on political instability except through the channel of income inequality. Figure 2.4(a) shows the relationship between ethnolinguistic fractionalization and income inequality, while Figure 2.4(b) shows the relationship between ethnolinguistic fractionalization and political instability. In the latter case, the assumption is that ethnolinguistic fractionalization works on political instability through the channel of income inequality (empirical justification is provided in the discussion of Table 2.1 in the results section).

2.3.2 Premodern channels (until 1500 CE)

Three channels have so far been discussed through which post-1500 redistribution of agricultural factor endowment, evolution of inequalities and institutions affect current income inequality. Today's income inequality is also connected to pre-modern development, and various historic events that occurred before 1500 in many ways. The ideas of pre-modern development that relate to income distribution today, are drawn primarily from the works of Ashraf and Galor (2013), Diamond (1997), Olsson and Hibbs Jr (2005), Comin *et al.* (2010), and Putterman and Weil (2010).

Before 1500 CE, there were a number of distinct ancestral groups in various regions across the world (Ashraf & Galor 2013). They were genetically distinct and, prior to mass migration, had been adapting to their specific environment for tens of thousands of years. This resulted in gradual development in technologies, and formation of political states within the groups. Their traits remained almost intact until the mass migration was yet to kick off after Columbus's discovery of America in the year 1492. Putterman and Weil (2010) argue that the human capital, knowledge and experiences of ancestral groups, accumulated for thousands of years, lead to inequality when those groups come together in the current states.

For many countries, the ancestors of current population are heterogeneous. The current population of any given country therefore bear traits from their ancestors, who had lived separately in various places on earth. The Human Genome Development Project

(HGDP) identified 53 such ancestral groups, which did not mix with each other much before 1500 CE. As a result, they are more intact in terms of their many ancestral traits, including genes. The ancestors had a dissimilar genetic background, and were exposed to a diversified bio-geographical environment for long that helped them to acquire different levels of technology and state experiences. Putterman and Weil (2010) find that people from various ancestral backgrounds have different levels of human capital, knowledge, culture and institutions. Once they are living together in today's world, they provide a variation in the income level across groups that can explain the current income inequality of that country.

We connect the variation of long run historical factors to current income inequality based on Putterman and Weil's (2010) hypothesis. They specifically analysed the variations in the state history and the timing of agricultural transition of the ancestors of the current population of a country. Similar to Putterman and Weil (2010), to capture the variation in the income levels across the groups, we also construct weighted average standard deviation[2] of various pre-modern historical factors that explain current income inequality.

In addition to Putterman and Weil's measures of state history and timing of agricultural transition, we measured weighted average standard deviation of other historical factors such as the migratory distance of ancestors, and the basic technologies they used. We also use a weighted average standard deviation of genetic diversity (measured by allelic frequency) of our ancestor groups, which reflects the innate ability a portion of population fraction inherits through the genetic background.

We provide short notes on the historical factors in the following subsections. Putterman and Weil (2010) successfully established the connection between the variations of early development indicators and today's income inequality, reporting that higher incomes to go to the people with richer ancestral backgrounds. Their hypothesis may not explain income

[2] Standard deviation throughout the paper refers to the weighted average standard deviation, where population fraction of a particular group is used as weight. The population fraction comes from Putterman's World migration matrix.

inequality of the countries with a more homogenous background in the general population, however. For example, countries such as China, Japan, Algeria, Finland, and Greece do not have a segment of the population with a foreign ancestral background. Today, as a result, their hypothesis may not explain the inequality in those countries. We therefore reduced the sample size to avoid those countries which have very low variation of early development indicators, measured by weighted average standard deviation of ancestral traits. In the case of standard deviation of state history, we excluded the observations with log of standard deviation of state history<-5, for example.

2.3.2.1 State history (in 1500 CE)

Chanda and Putterman (2007) provide a composite measure of the state history of the population of countries in the year 1500. It refers to the early development of political institutions in a country, and is measured with three basic components that reflect (1) the presence of a government above the tribal level in a country, (2) whether this government is locally based or foreign, and (3) the proportion of the current territory covered by this government. Each of the components is given a score between 0 and 50 for every fifty years since 1CE. Based on Putterman and Weil (2010), we measure it through the following equation:

$$State\ History\ (1500\ CE) = \frac{\sum_{t=1}^{30}(1.05)^{1-t} * S_{i,t}}{\sum_{t=1}^{30}(1.05)^{1-t} * 50} \qquad (3)$$

where $S_{i,t}$ represents the state history for country *i* for a fifty-year period *t*. For each of the period *t*, we apply a five percent discount rate to account for the diminishing effects of political institutions formed in the earlier past.

2.3.2.2 Technology (in 1000 BCE)

We use the variation of the use of early technology in 1000 BCE to predict today's income inequality. The data comes from Comin *et al.* (2010), who documented a persistent relationship between technology in the early development stages with technology and per capita income today. As a result, it is plausible to explain that the traits of the ancestors with higher exposure to ancient technologies could have transmitted the knowledge to obtain a higher income in today's society to their descendants. The level of technology of 1000 BCE was very basic, including pack animals and wheeled vehicles, among 12 different technologies in total. Comin *et al.* (2010) measured this technology in 1000 BCE on the basis of the availability of those technologies, not based on how intensively they had been used. They calculated the average adoption rate of each technology first. The overall adoption level is then taken as the unweighted average adoption rates for all of them, which yields an index value between 0 and 1 for the extent of technological adoption.

2.3.2.3 Timing of Agricultural Transition

Diamond (1997) provides a descriptive account of the timing of agriculture. He finds that countries endowed with richer biological and geographical environments experienced earlier transition to agriculture. Following Diamonds notions, Olsson and Hibbs Jr (2005) documents data of the timing of agricultural adoption, and empirically justifies that the present-day income of a country is in direct correlation with its earlier transition to agriculture. Putterman and Weil (2010) find a strong association between the variation of timing of agricultural transition and current income inequality. Their timing of agriculture adoption data is based on a time when humans started deriving more than 50% of the calorific needs from cultivated plants and domesticated animals. Our work also connects the variation of agricultural transition timing to current income inequality to exploit the latter's connection to political instability. The weighted average of the standard deviation of agricultural transition time is calculated using Putterman's (2006) data and his World Migration Matrix.

2.3.2.4 Migratory Distance

Homo sapiens, the only species of human currently living on earth, evolved around 150,000 years ago. Around 70,000 years ago they started moving out of East Africa (currently Addis Ababa, Ethiopia), mainly through a few specific routes and dispersed throughout the world. The migratory distances the ancestors of a current population group of a country had walked from the cradle of humanity (Addis Ababa) before they settled, can indicate the variation of today's income inequality, based on the notion that groups that walked greater migratory distances are on the lower rungs of the income ladder .

In fact, the genetic diversity (allelic frequency) of a group has a high association with the migratory distance their ancestors walked. The genetic diversity reduced as human walked longer migratory distance. The relationship is based on the serial founder effect, which states that human in the prehistoric era, when departing from one place to go to another, lost part of the variation in their alleles, as they only carry a subset of the original set of genes. Consequently each time a group departs from the main group, they lose some elements of the group's genes. Those groups that walked the largest migratory distances therefore seem to have lowest variations in their alleles. Therefore, groups that walked longer migratory distances, or possess lower genetic diversity, could have lower income among the groups.

2.3.2.5 Genetic diversity

Genetic diversity refers to the variation of the genes across population groups. It measures the expected heterozygosity that explains the probability of two individuals selected randomly from a population to end up in different allelic frequencies. Based on Putterman and Weil's (2010) hypothesis, we argue that the variation in genetic diversity of current population groups would pick up the variations in the income of the ancestral genetic groups.

We use genetic data from Ashraf and Galor (2013), which uses 53 ethnic groups among indigenous populations across the world. The data originally comes from HGDP-CEPH Diversity Panel Database, which is said to be a more reliable and consistent dataset for genetic diversity. Ashraf and Galor (2013) however adjusted the data to accommodate the impact of nonindigenous ethnic groups in the population that might have initially migrated to their current locations due to the higher economic prosperity of these locations.

2.4. Results

2.4.1 Least square estimates

The least square estimates of Eq. (1) reported in Table 2.1 show a strong correlation between UNU-WIDER Gini and state fragility index. All the regressions include religion variables, as they assumed to have strong impact on state fragility. We also include ethnolinguistic fractionalization in column (1) to (4) to identify its impact on political instability. In column (1), the effect of income inequality is found to be positive, and this effect is statistically significant at the 1% level. In columns (2) to (4), we gradually include hydrocarbon reserves per capita, terrain ruggedness, and landlockedness as control variables, however, the results remain the same. Throughout columns (1) to (4), it seems that ethnolinguistic fractionalization affects state fragility only through the channel of income inequality. The R^2 value (0.48) also does not change across the regressions.

As there is no significant direct impact of ethnolinguistic fractionalization on political instability, in column (5), we drop ethnolinguistic fractionalization as a control variable, keeping in mind to use it as an instrument for income inequality in the subsequent regressions.

The results in column (5) are still significant at 1% level and with a high value of R^2. A one percentage point change in UNU-WIDER Gini increases political instability by 0.21%. We use specification in column (5) in the subsequent regressions to identify our benchmark model. The results in this Table have to be interpreted with cautions due to potential correlation between the measure of income inequality and the error term.

Table 2.1 Least square estimates

Dep. Var. = State Fragility Index	(1)	(2)	(3)	(4)	(5)
Income inequality (UNU-WIDER Gini)	0.18***	0.18***	0.18***	0.18***	0.21***
Beta coefficient	[0.45]***	[0.46]***	[0.45]***	[0.45]***	[0.52]***
	(0.043)	(0.043)	(0.045)	(0.044)	(0.042)
Hydrocarbon reserves per capita		-0.027	-0.032	-0.037	-0.035
		(0.074)	(0.074)	(0.078)	(0.079)
Terrain ruggedness			0.232	0.217	0.113
			(0.313)	(0.294)	(0.294)
Landlockedness				0.214	0.381
				(0.667)	(0.668)
Ethnolinguistic fractionalization	2.065	2.085	2.332	2.272	
	(1.845)	(1.823)	(1.861)	(1.872)	
Muslims	0.032***	0.031***	0.032***	0.033***	0.035***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
Protestants	-0.031	-0.031	-0.031	-0.030	-0.030
	(0.025)	(0.025)	(0.024)	(0.024)	(0.025)
Other religions	0.043***	0.043***	0.042***	0.042***	0.046***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)
Constant	-9.32***	-9.44***	-9.69***	-9.74***	-10.05***
	(2.39)	(2.40)	(2.39)	(2.38)	(2.42)
Observations	94	94	94	94	94
R-squared	0.48	0.48	0.48	0.48	0.47

Notes: Beta coefficients are in the square brackets. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. Catholic is the omitted religion variable.

2.4.2 Instrumental variable estimates

Table 2.2 reports the instrumental variable regression results where, absolute latitude, ethnolinguistic fractionalization and wheat-sugar ratio are used as instruments for the UNU-WIDER Gini index. Panel A provides the second stage regression results, while panel B provides the first stage results. Compared to the least square results in Table 2.1, the magnitude of the coefficient estimates increased substantially. The relatively larger coefficients of income inequality obtained in panel A suggest that the instrumental variable estimation could be an appropriate approach, since the OLS estimates are measured with errors. Column (1) to (3) uses each of the instruments alone, while in column (4) to (6) any two of them are combined in different ways. In column (7), finally, we combine all the three instruments together. None of the estimated coefficients of income inequality seems to be significantly different from others. The magnitudes are largely the same. The overidentification test results (p-values) reported in column (4) to (7) supports the identification of our benchmark model.

Table 2.2 Instrumental variable estimates

Dep. Var. = State Fragility Index	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Panel A: Second-stage results						
UNU-WIDER Gini	0.33***	0.30***	0.35***	0.32***	0.36***	0.34***	0.35***
Beta coefficients	[0.84]***	[0.76]***	[0.87]***	[0.82]***	[0.88]***	[0.84]***	[0.86]***
	(0.06)	(0.07)	(0.08)	(0.06)	(0.07)	(0.07)	(0.06)
Observations	94	94	91	94	91	91	91
R-squared	0.34	0.42	0.38	0.40	0.38	0.40	0.39
Overidentification (p-value)				0.671	0.940	0.736	0.912
	Panel B: First-stage results						
Absolute latitude	-0.38***			-0.32***	-0.33***		-0.26***
	(0.05)			(0.05)	(0.06)		(0.06)
Ethnolinguistic fractionalisation		19.16***		8.31**		14.34***	8.41**
		(3.42)		(3.26)		(3.28)	(3.28)
Wheat-sugar ratio			-22.2***		-4.76	-17.3***	-5.41
			(3.90)		(3.94)	(3.84)	(4.25)
R-squared	0.51	0.35	0.34	0.54	0.51	0.45	0.54
Partial R-squared	0.424	0.237	0.234	0.458	0.410	0.354	0.446
F-stat. (excl. instrument)	60.7	31.1	33.6	31.0	26.9	23.2	18.3

Notes: Beta coefficients are in the square brackets. Estimates of control variables and the constant in the regressions are not reported for brevity. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

In panel B, the results reported in the first three columns indicate the strength of each individual instrument. Column (4) to (7) results depict that they are also strong in combination. The coefficient estimates of UNU-WIDER Gini index are significant both economically and statistically. The partial R^2 and F-statistic for the excluded instruments across the columns indeed reinforce the support in favor of the instruments for income inequality.

We use the specification in column (7) as our benchmark regression. On average, a one percentage point change in Gini (ranging between 0 and 100) is associated with a 0.35% increase in political instability, measured by state fragility index. Alternatively, a one standard deviation change in UNU-WIDER Gini has a 0.86 standard deviation impact on state fragility index. This effect is very precisely estimated at the 1% level of statistical significance, and the results are remarkably consistent.

2.4.3 Exclusion restrictions test

The above findings are based on the assumption that income inequality is the mechanism through which the ethnolinguistic fractionalization, the initial distribution of agricultural endowment and the institutions across the world influence current political instability. Hence, the exclusion restriction implied by our instrumental variable strategy is that the absolute latitude, ethnolinguistic fractionalization, and wheat-sugar ratio have no direct impact on current political instability, other than through their effect on income inequality. To test the validity of this assumption, we use simple exclusion restriction tests.

The results for the exclusion restriction tests are reported in Table 2.3. As the main idea is that a successful instrument will work only through the income inequality variable, not directly affecting the dependent variable, it is plausible that controlling for any of the instruments in the second stage then should end up with insignificant impact on the political instability measure. Throughout the columns, we perform this simple exclusion restriction test.

Table 2.3 Exclusion restriction tests

D.V=SFI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Panel A: Second-stage results								
UNU-WIDER Gini	0.24	0.35***	0.36***	0.33	0.36***	0.31***	0.27	0.37***	0.34***
Beta coefficients	[0.60]	[0.88]**	[0.90]**	[0.80]	[0.90]**	[0.77]**	[0.68]	[0.92]**	[0.85]**
	(0.188)	(0.087)	(0.100)	(0.417)	(0.107)	(0.102)	(0.193)	(0.090)	(0.082)
Absolute latitude	-0.034			-0.012			-0.03		
	(0.075)			(0.153)			(0.075)		
Ethnolinguistic		-0.906			-0.714			-0.89	
Fractionalization		(2.134)			(2.202)			(2.103)	
WSR			0.214			-0.933			-0.18
			(2.831)			(2.762)			(2.48)
Observations	94	94	91	91	91	91	91	91	91
R-squared	0.483	0.365	0.369	0.419	0.369	0.432	0.473	0.355	0.393
Overid p- value							0.875	0.890	0.688
Additional control	IV1	IV2	IV3	IV1	IV2	IV3	IV1	IV2	IV3
Excluded IVs	IV2	IV1	IV1	IV3	IV3	IV2	IV2+IV3	IV1+IV3	IV1+IV2
	Panel B: First-stage results								
Absolute latitude	-0.31***	-0.31***	-0.32***	-0.32***			-0.25***	-0.25***	-0.25***
	(0.05)	(0.05)	(0.06)	(0.06)			(0.06)	(0.06)	(0.06)
Ethn. fractionalization	8.17**	8.17**			13.65***	13.65***	8.28**	8.28**	8.28**
	(3.29)	(3.29)			(3.24)	(3.24)	(3.28)	(3.28)	(3.28)
WSR			-5.76	-5.76	-17.8***	-17.8***	-6.34	-6.34	-6.34
			(3.84)	(3.84)	(3.91)	(3.90)	(4.11)	(4.11)	(4.11)
R-squared	0.546	0.546	0.514	0.514	0.468	0.468	0.544	0.544	0.544
Partial R-squared	0.059	0.289	0.229	0.015	0.172	0.157	0.076	0.290	0.277
F-stat (first stage)	6.16	35.0	30.3	2.25	20.8	17.7	3.92	16.7	16.7

Notes: Beta coefficients estimates are reported in the square brackets. Estimates of control variables and the constant in the regressions are not reported for brevity. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. IV1=Absolute latitude, IV2=Ethnolinguistic fractionalization, and IV3=Wheat-sugar ratio has been used as instruments for UNU-WIDER Gini index.

In column (1), we report the result by controlling for absolute latitude in the second stage, while ethnolinguistic fractionalization has been used as the excluded instrument. The results depict no significant impact of absolute latitude on state fragility index in the second stage. Throughout the regressions, the same is true as we account for one of the instruments as control variable in the second stage, while the other instruments or their combination are used as excluded instruments. None of the instruments in any column shows any significant impact on our dependent variable in the second stage, justifying the validity of our instruments.

In panel B, the first stage regression outputs are reported. Across the regressions, although the strength of the instruments varies in different combinations, they capture the variation in the UNU-WIDER Gini index successfully.

2.4.4 Additional instrumental variable estimates

Until now we report the results that predict current income inequality with the current ethnolinguistic variation, the evolution of institutions, and structural inequality in the post Columbian era, proxied by ethnolinguistic fractionalization, absolute latitude, and the agricultural resource endowments. In Table 2.4, we show how early ancestral backgrounds are related to today's political instability through their connection to income inequality.

Table 2.4 Robustness check with Pre-modern development indicators as instruments

D.V.=SFI	(1a) IV4	(1b) IV5	(1c) IV4+IV5	(2a) IV6	(2b) IV7	(2c) IV8	(2d) IV6+IV7	(2e) IV6+IV8	(2f) IV7+IV8	(2g) IV6+IV7+IV8
Panel A: Second-stage results (using WSR and latitude as instruments)										
UNU-WIDER Gini	0.26***	0.26**	0.27***	0.28***	0.39***	0.32***	0.35***	0.30***	0.41***	0.38***
Beta coefficients	[0.66]***	[0.66]**	[0.68]***	[0.70]***	[0.99]***	[0.77]***	[0.90]***	[0.71]***	[1.02]***	[0.94]***
	(0.072)	(0.107)	(0.076)	(0.078)	(0.091)	(0.105)	(0.086)	(0.082)	(0.092)	(0.088)
Observations	78	77	77	75	72	73	70	73	68	68
R-squared	0.483	0.489	0.484	0.491	0.349	0.478	0.429	0.496	0.381	0.431
Overid. P-value			0.888				0.094	0.609	0.581	0.418
Panel B: First-stage results										
SDSHIST (IV4)	70.7***		70.7***							
	(10.42)		(14.61)							
TECH1000BCE (IV5)		38.0***	-1.28							
		(10.89)	(12.25)							
SDAGYEARS (IV6)				9.234***			7.176**	7.982***		5.332
				(1.580)			(3.499)	(2.599)		(4.134)
SDMDIST (IV7)					2.295***		0.756		1.590***	0.794
					(0.390)		(0.850)		(0.550)	(0.860)
SDPDIV (IV8)						26.640***		5.597	15.418*	8.27
						(6.500)		(9.817)	(8.813)	(9.929)
R-squared	0.464	0.278	0.463	0.434	0.389	0.359	0.45	0.468	0.465	0.494
Partial R-squared	0.246	0.125	0.349	0.196	0.290	0.202	0.354	0.338	0.329	0.365
F-stat (excl. IV)	29.2	12.2	20.8	18.2	36.9	16.8	22.5	16.4	20.4	14.2

Notes: Beta coefficients estimates are reported in the square brackets. Estimates of control variables and the constant in the regressions are not reported for brevity. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. IV1=Absolute latitude, IV2=Ethnolinguistic fractionalization, and IV3=Wheat-sugar ratio has been used as instruments for UNU-WIDER Gini index. Notations: *SDSHIST=Weighted average standard deviation of state history; TECH1000BCE= Weighted average standard deviation of technology in the year 100 BCE; SDAGYEARS= Weighted average standard deviation of timing of agriculture adoption; SDMDIST= Weighted average standard deviation of migratory distance; SDPDIV=Weighted average standard deviation of predicted genetic diversity*

In column (1a) and (1b), we use standard deviation of state history and standard deviation of available 1000 BCE technologies of the ancestors of the current population as instruments for income inequality. In Column (1c) we use their combination. The results are significant, and the regressions pass overidentification tests, along with the partial R^2 values and F-statistics of the excluded instrument in the first stage.

In column (2a) to (2g), we use standard deviation of the timing of agriculture adoption, standard deviation of migratory distance, and standard deviation of predicted genetic diversity of the ancestors of the current population as instruments. Again, both individually, and in combination, the instruments predict the relationship between income inequality and political instability, capturing the variations in the income inequality measure. The results are highly significant along with successful overidentification tests in the second stage and with high values of F-statistic and partial R^2 in the first stage. The results reinforce the relationship between income inequality and political instability delving into the ancestral background of current population.

2.4.5 Alternative income inequality and political instability measures

Income inequality has so far been measured using the UNU-WIDER Gini coefficient, whereas political instability has been measured by the State Fragility Index. It is not clear, however, if the results still prevail when alternative measures are used. Panel A of Table 2.5 reports that our previous findings remain largely unchanged when political instability is measured using the Failed State Index (column (1a)) or The World Bank's political instability rankings (column (1b)).

Moreover, the results are broadly consistent when income inequality is measured using the Gini coefficient estimates from The World Bank's World Development Indicators (column (2a)) or Solt Gini index (column (2b)). We report only the beta coefficients of income inequality measures for the ease of comparing the results in terms of corresponding changes in the standard deviations of the political instability measures. The coefficient estimates in panel A are supported by the first stage results.

Table 2.5 Alternative income inequality and political instability measures

	(1a)	(1b)	(2a)	(2b)
	PI=Failed State Index	*PI=WB's Political Instability Rankings*	*Ineq= WDI Gini*	*Ineq= Solt's Gini*
	Panel A: Second-stage results			
Beta coefficients (UNU-WIDER Gini)	**0.95*****	**0.79*****		
(WDI Gini)			**1.16*****	
(Solt Gini)				**1.31*****
Observations	90	90	72	82
R-squared	0.493	0.508	0.260	
Overidentification test (p-value)	0.856	0.248	0.985	0.643
	Panel B: First-stage results			
Absolute latitude	-0.246***	-0.246***	-0.087	-0.141***
	(0.073)	(0.073)	(0.090)	(0.046)
Ethnolinguistic fractionalization	9.05**	9.05**	11.68***	0.967
	(3.670)	(3.670)	(4.157)	(3.443)
WSR	-6.92	-6.92	-12.06**	-6.715*
	(4.54)	(4.54)	(5.791)	(3.504)
R-squared	0.563	0.563	0.602	0.466
Partial R-squared	0.449	0.449	0.408	0.297
F-statistics (excluded instrument)	18.4	18.4	11.7	7.83

Notes: Beta coefficients estimates are reported for the inequality measures only. Estimates of control variables and the constant in the regressions are not reported for brevity. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. IV1=Absolute latitude, IV2=Ethnolinguistic fractionalization, and IV3=Wheat-sugar ratio has been used as instruments for UNU-WIDER Gini index.

2.4.6 Alternative sample analysis

In this section, we perform analysis using different sub-samples. First, the Engerman-Sokoloff hypothesis was originally developed to explain the unequal development in Latin America and the Caribbean. It is not clear if the same principle can be applied to countries outside the continent. In column (1a) of Table 2.6, we exclude the countries in the American continent. The coefficient of income inequality remains very precisely estimated at the 1% level. This suggests that the hypothesis can explain a worldwide phenomenon, not specific to any particular group of countries. Next, in column (1b), all African countries are removed from the analysis to check if our results are driven by the quality of data. We do not find any substantial variation in the results.

Table 2.6 Alternative samples

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
	Exclude America	*Exclude Africa*	*Exclude low GDP per capita countries*	*Exclude high GDP per capita countries*	*Exclude low credit/GDP countries*	*Exclude high credit/GDP countries*	*Exclude low secondary enrolment rate countries*	*Exclude high secondary enrolment rate countries*
	Panel A: Second-stage results							
Beta coefficient (UW Gini)	**[0.77]*** **	**[0.89]*** **	**[0.72]*** **	**[1.51]** **	**[0.66]*** **	**[1.55]*** **	**[0.52]*** **	**[0.52]**
Overid. P-value	0.861	0.698	0.655	0.180	0.980	0.139	0.731	0.236
	Panel B: First-stage results							
Absolute latitude	-0.217***	-0.254***	-0.399***	-0.03	-0.450***	-0.094	-0.328***	0.204
	(0.066)	(0.073)	(0.089)	(0.134)	(0.101)	(0.092)	(0.077)	(0.129)
Ethn. fractionalization	9.670**	5.334	8.981*	11.287**	6.688	8.679*	7.246**	20.137***
	(3.650)	(3.602)	(5.253)	(4.484)	(4.983)	(4.774)	(3.556)	(4.292)
WSR	-5.637	-6.349	1	-9.303	-3.758	-4.64	-3.279	-6.548
	(4.255)	(4.355)	(4.340)	(6.920)	(4.383)	(5.870)	(4.216)	(4.747)
Observations	72	69	44	47	44	47	46	45
R-squared	0.517	0.606	0.63	0.601	0.641	0.511	0.566	0.623
Partial R-squared	0.438	0.438	0.552	0.214	0.604	0.218	0.502	0.323
F-stat (first stage)	13.9	12.0	7.94	3.72	13.6	2.65	13.2	7.8

Notes: Beta coefficients estimates are reported in the square brackets. Estimates of control variables and the constant in the regressions are not reported for brevity. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. IV1=Absolute latitude, IV2=Ethnolinguistic fractionalization, and IV3=Wheat-sugar ratio (WSR) has been used as instruments for UNU-WIDER Gini index.

Development, whether it is economic, financial or human capital, in general, has a narrowing effect on political instability. Increase in per capita GDP may reduce political instability as poor might remain patient to reap the benefit of redistribution of surplus in near future (Sigelman & Simpson 1977). Similarly, human capital development and financial development may hold back political instability. Collier and Hoeffler (2004) argue that secondary school enrolment rate increases the opportunity cost of political participation, thereby supports political stability. On the other hand, Beck *et al.* (2007) finds financial development to reduce income inequality, which may further have an impact on political stability.

Column (2a) excludes the countries in the bottom of the distribution ranked by income per capita less than USD 6000[3], whereas column (2b) does not consider countries with income levels above USD 6000. In both cases, we continue to find a very significant effect of income inequality, although unsurprisingly such an effect is found to be much smaller in countries with higher income levels. This is probably due to the fact that rich countries can afford, or are more likely to adopt, systems that promote redistribution of wealth, thus ameliorating the negative effects of income inequality on political stability.

Columns (3a) and (3b) repeat the same exercise by grouping the countries based on their levels of financial development[4]. As in the previous case, financially less developed countries tend to experience higher political instability, when income inequality exacerbates. In columns (4a) and (4b), countries are split based on their levels of educational achievements.[5] The impact of inequality on political instability seems to be insignificant in the low-enrolment countries, although it is significant in the high-enrolment ones. It could be due to the fact that in the countries where the average years of schooling is low, the poor who are the less educated group, are easily controlled by the educated rich.

2.4.7 Further robustness checks

In the previous section we found how the impact of inequality on political instability differs in countries with different levels of economic, financial and human capital development. However, it is not yet clear if the level of development have any direct impact on political instability, other than through the channel of inequality. Therefore, in columns (1) to (4) in Table 2.7, we directly control for per capita income, income growth, financial

[3] In the year 2000
[4] 1990-99 average domestic credit/GDP greater than 0.16 in one group and the rest in the other
[5] 1990-99 average school enrolment rate (male and female who are above 25 years of age) greater than 9 years in one group and the rest in the other

development, and secondary enrolment rates for the full sample. None of the development variables seem to have any direct impact on political instability.

In the literature, the impact of urbanization on political instability is not much clear. Kuznets (1955) argues that given higher per capita income, inequality is more prevalent in the urban areas. Urbanization may reduce political instability as it encourages poor to be patient to derive benefit of redistribution. On the other hand, urban poor can easily demonstrate against the system in the big cities to draw the attention of the government, public and media (Huntington 1968; Hibbs 1973). However, we do not find any significant impact of urbanization in our results reported column (5).

There is a consensus in the literature that trade openness could reduce political instability. The more a country is involved in international trade, the more it promotes peace and stability (Viner 1937), as it increases commitment to international community, and also increasingly become members of trade and international organizations. In column (6), we report the impact of trade openness, but do not find any impact on political instability.

Regarding land inequality, it is necessary, though not sufficient, condition for the likelihood of revolution. Huntington (1968) argues that greater inequality in the distribution of land poses greater possibility of mass-based political insurgency. However, opposite views also exist. For instance, Muller and Seligson (1987) argue that agrarian inequality is relevant only to the extent it is associated with inequality in the nationwide distribution of income. We do not find impact of land inequality on political instability other than through income inequality.

We also do not find any impact on political instability from colonial source variations, and additional geographical variables such as distance from coast, percent of desert, and average elevation. As shown in Table 2.7, our overall results remain robust to the inclusion of the additional controls.

Table 2.7 Additional controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Add Per capita GDP	*Add per capita GDP growth*	*Add domestic credit-GDP ratio*	*Add secondary enrolment rate*	*Add Urbani-zation*	*Add trade openness*	*Add land Gini*	*Add colonial source of variation*	*Add additional geo-graphic variables*
	Panel A: Second-stage results								
Beta coefficient (Gini)	**[.67]*****	**[.85]*****	**[.85]*****	**[.99]*****	**[.89]*****	**[.90]*****	**[.93]*****	**[.90]*****	**[.83]*****
	(0.08)	(0.06)	(0.06)	(0.09)	(0.07)	(0.06)	(0.08)	(0.09)	(0.05)
GDP per capita	-3.34								
	(2.87)								
GDP per capita growth		0.035							
		(0.09)							
Domestic credit/GDP			-0.007						
			(0.01)						
Secondary enrolment				0.157					
				(0.22)					
Urbanization					0.005				
					(0.02)				
Trade openness						0.956			
						(2.5)			
Land Gini							-1.192		
							(1.8)		
Colonial source								-0.055	
								(0.20)	
Distance from coast									-1.004
									(0.95)
%Desert									0.017
									(0.03)
Average elevation									0.879
									(0.60)
Observations	89	90	89	82	91	90	67	91	90
R-squared	0.497	0.4	0.412	0.334	0.375	0.377	0.433	0.369	0.419
Overid. P-value	0.985	0.953	0.916	0.695	0.878	0.915	0.948	0.851	0.975
1SLS	Panel B: First-stage results								
Absolute Latitude	-0.18**	-.24***	-0.24	-0.20***	-0.31***	-0.23***	-0.27***	-0.20*	-0.30***
	(0.08)	(0.06)	(0.06)	(0.073)	(0.067)	(0.071)	(0.067)	(0.10)	(0.074)
Ethn. fractionalization	6.839**	9.360***	8.09	9.077**	8.087**	8.170**	7.173*	8.471**	6.35
	(3.391)	(3.347)	(3.48)	(3.929)	(3.129)	(3.426)	(3.903)	(3.342)	(4.040)
WSR	-3.447	-6.343	-4.92	-7.1	-7.696*	-6.481	-4.844	-6.498	-4.35
	(4.233	(3.966	(4.19)	(4.521	(3.962	(4.244	93.84	(4.235	(4.640)
Observations	89	90	89	82	91	90	67	91	90
R-squared	0.562	0.556	0.549	0.549	0.563	0.545	0.643	0.549	0.556
Partial R-squared	0.185	0.446	0.388	0.276	0.430	0.416	0.449	0.241	0.448
F-stat (excl. IV)	4.71	17.4	11.8	9.77	17.1	15.9	13.4	6.62	19.0

Notes: Beta coefficients estimates are reported in the square brackets. Estimates of control variables and the constant in the regressions are not reported for brevity. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. IV1=Absolute latitude, IV2=Ethnolinguistic fractionalization, and IV3=Wheat-sugar ratio (WSR) has been used as instruments for UNU-WIDER Gini index.

2.5 Conclusions

This study reinforces the possibility that political instability is an outcome of income inequality, which can be traced back to the long term history of development. Long-term history includes post-Columbian colonization, evolution of institutions, and migration. It also covers pre-Columbian formation of states, the discovery and use of basic technologies, and deep rooted factors such as the timing of agricultural adoption and the migratory distances walked by our ancestors in the course of prehistoric exodus of Homo sapiens out of Africa. The work also connects the genetic diversity of the population of a country with income inequality to explore the latter's impact on political instability.

The historical and prehistoric data provide us consistent estimates of the impact of income inequality on political instability. Using cross-sectional data for 96 countries, a one standard deviation increase in UNU-WIDER Gini seems to be associated with around a 0.8 standard deviation increase in the state fragility index of Center for Systemic Peace. The results in this paper indicate that income inequality and political instability are indeed positively correlated, and they have roots in the long term historical factors of development- from the departure of humans from East Africa to the recent history of colonization and mass migration.

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Appendix

Table 2.A1 Description of variables and data sources

Variable	Description	Source
State Fragility Index	Data are based on four basic concepts associated with the security, social, political and economic development of a country. For each of these dimensions, effectiveness and legitimacy indices are measured. Except for “economic effectiveness”, which is measured on a 0 to 4 scale, all indicators are rated on a scale of 0 to 3 with a larger value reflecting higher fragility. The sum of these eight components reflects the overall fragility (on 0-25 scale). We take average for 2000-2009.	INSCR data page of Center for Systemic Peace
Failed State Index	Data are based on 12 social, economic and political indicators on a scale of 0-10. The sum gives overall fragility (0-120 scale). We take average for 2000-09.	Fund for Peace data page
Political instability rank	Based on ranking data for political instability where 0 indicates full instability and 100 means full stability. Political instability here refers to the likelihood that the government in power will be destabilized or overthrown by violent means. We compute political instability by subtracting the data from 100, where 0 refers to full stability and 1 refers to full instability. Average data for the period 2000-2009 are used.	World Bank Governance Indicators (2012)
UNU-WIDER Gini Index	Gini Index from the UNU-WIDER (0-100).	UNU-WIDER Database (2012)
WDI Gini Index	Gini Index from the World Bank (0-100).	World Development Indicators (2012)
Solt Gini	Gini index from the Standardized World Income Inequality Database (SWIID) (0-100).	Solt (2009)
Wheat-sugar ratio	This ratio is defined as log[(1+ Share of arable land suitable	Easterly (2007)

	for wheat)/ (1+ Share of arable land suitable for sugarcane)].	
Latitude	Absolute latitude of a country (scaled to 0-1).	La Porta *et al.* (1999)
Distance from coast	Average distance to nearest ice-free coast in 1000 kilometres.	Ashraf and Galor (2013)
Desert	A countries per cent area in a desert.	Ashraf and Galor (2013)
Elevation	Mean elevation of a country.	Michalopoulos (2012)
Ethnolinguistic fractionalization	An index capturing the extent of ethnic and linguistic heterogeneity within the population (scaled to 0-1).	Alesina *et al.* (2003)
Hydrocarbon reserves per capita	Logarithm of per capita hydrocarbon reserves in 1993 (in 1000 BTU).	Gallup *et al.* (1999)
Religion variables	Percentage of the population in each country that belonged to Catholic, Protestant, Muslim or others in 1980.	La Porta *et al.* (1999)
Landlockedness	A dummy variable that equals 1 if a country is fully enclosed by land and 0 otherwise.	Gallup *et al.* (1999)
Terrain ruggedness	Measures small-scale terrain irregularities in each country in terms of elevation differences.	Nunn and Puga (2012)
Per capita GDP	Per capita GDP in 1990 International Geary-Khamis dollars.	Maddison (2003)
Domestic credit	Credit provided by the domestic banking sector as % of GDP.	World Development Indicators (2012)
Urbanization	Percentage of total population living in urban areas as defined by national statistical offices.	World Development Indicators (2012)
Average school enrolment rate	1990-99 average school enrolment rate of male and female who are above 25 years of age.	From barrolee.com
Agricultural Transition data	The period in Millenia between 2000 CE and the timing of agricultural transition in a country	Putterman (2006)
Protection against expropriation	Average protection against expropriation risk refers to the risk of expropriation of private foreign investment by the government. The data is average of 1985-1995, and measured in a scale of 0-10, where lower score means higher risk. The data originally comes from Political Risk services, and used by Knack and Keefer (1995), and Acemoglu *et al.* (2001).	Acemoglu *et al.* (2001)
Rule of law	Rule of law is one of the six World Bank Governance Indicators. It captures the extent the citizens obey the law, and the level of confidence they have on it. It in particular includes property rights, the police and the courts, the quality of contract enforcement, and the likelihood of crime and violence.	World Development Indicators (2012)
Per capita GDP growth	Annual growth rate of real GDP per capita	World Development Indicators (2012)
Executive constraints	Constraint on executive refers to the extent of institutionalized restrictions a chief executive faces over his decision-making power. It is measured between 1 and 7, where 1 indicates unlimited power and 7 indicates executive parity or	Ashraf and Galor (2013)

	subordination. The data is originally from Polity IV dataset (Marshall & Jaggers 2005)	
Quality of public institutions	It refers to the average value of the ICRG variables "Corruption", "Law and Order" and "Bureaucracy Quality, each of which is scaled between 0 and 1, where 0 indicates the lowest quality of governance.	Teorell *et al.* (2013)
World Migration matrix	It provides the estimated proportions of the current population, whose ancestors lived in other places in the year 1500.	Louis Putterman's Brown University webpage
Standard deviation of timing of agricultural transition	It refers to the weighted average standard deviation of timing of agricultural transition from current time (in 1000 years). The timing of agricultural transition data mainly comes from Putterman (2006). Population proportions from World Migration Matrix are used as weights.	Authors own calculation. Data from Louis Putterman's Brown University website
Standard deviation of state history	It refers to the weighted average standard deviation of state history in 1500 CE. The state history data originally comes from Chanda and Putterman (2007). Population proportions from World Migration Matrix are used as weights.	Authors own calculation. Data (version 3.1) from Louis Putterman's Brown University website
Standard deviation of predicted genetic diversity	It refers to the weighted average standard deviation of predicted genetic diversity. Population proportions from World Migration Matrix are used as weights.	Authors own calculation. Data from Putterman's migration matrix and Ashraf and Galor (2013)
Standard deviation of migratory distance	It refers to the weighted average standard deviation of migratory distance. Population proportions from World Migration Matrix are used as weights.	Authors own calculation. Data from Putterman's migration matrix and Ashraf and Galor (2013)

Table 2.A2 Summary statistics of the variables

Variable	(1) Observations	(2) Mean	(3) Std. dev.	(4) Min	(5) Max
State fragility index	95	0.50	3.97	-13.82	3.02
Failed state index	93	4.10	0.47	2.93	4.67
Political instability rank	95	0.84	0.16	0.00	0.99
UNU-WIDER Gini	95	40.82	10.01	24.96	61.65
WDI Gini	76	41.50	9.74	24.70	61.33
Solt Gini	86	44.45	7.13	28.07	64.48
Hydrocarbon reserve per capita	95	0.44	4.32	-4.61	8.03
Terrain ruggedness	95	1.27	1.12	0.04	6.20
Land lockedness	95	0.26	0.44	0.00	1.00
Absolute latitude	95	29.72	17.90	1.00	64.00

Ethnolinguistic fractionalization	94	0.41	0.25	0.00	0.93
Wheat-sugar ratio	92	0.12	0.20	-0.33	0.58
St. dev. of state history	95	0.09	0.09	0.00	0.29
St. dev. of 1000 BCE technology	77	0.13	0.09	0.00	0.40
St. dev. of Timing of agri. adoption	89	0.18	0.16	0.00	0.55
St. dev. genetic diversity	73	0.29	0.16	0.06	0.68
St. dev. of migratory distance	74	2.99	2.71	0.00	9.69
Constraint on executives	94	4.47	1.94	1.10	7.00
Protection against expropriation	75	7.50	1.67	4.00	10.00
Quality of public institutions	72	6.05	2.33	2.27	9.98
Rule of law (WDI)	94	0.05	1.04	-1.64	1.97
GDP per capita	93	0.28	0.27	0.02	1.00
GDP per capita growth	93	3.24	2.97	-5.22	12.25
Colonial source variation	94	2.27	2.64	0.00	10.00
Average school attainment (years)	84	8.33	2.90	1.44	13.27
Urbanization	95	57.43	22.06	9.30	97.25
pwt_openk3	94	0.30	0.17	0.00	0.75
Land Gini	71	0.51	0.29	-0.01	1.00
Distance from coast	95	0.39	0.45	0.01	2.21
Desert	95	3.60	11.19	0.00	74.86
Average elevation	94	0.61	0.55	0.02	2.84

Table 2.A3 Correlation coefficients of the key variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) State fragility index	1						
(2) Failed state index	0.90	1					
(3) Political instability rank	0.81	0.89	1				
(4) UNU-WIDER Gini	0.54	0.53	0.47	1			
(7) Absolute latitude	-0.70	-0.69	-0.66	-0.67	1		
(8) Ethnolinguistic fractionalization	0.56	0.55	0.45	0.46	-0.50	1	
(5) Wheat-sugar ratio	-0.57	-0.51	-0.47	-0.52	0.66	-0.31	1

Chapter 3: Genetic Distance, Economic Growth and Top Income Shares in the OECD Countries

Abstract: The endogeneity between income inequality and economic growth seems to be impregnable in the literature. Despite the large body of literature, there is as yet no instrument of either income inequality or economic growth that accounts for the causality between the two. Motivated by Spolaore and Wacziarg's (2009) influential idea that the genetic distance between populations of countries puts a barrier in the way of the diffusion of development, this work uses the weighted average growth of other countries as an instrument for economic growth that can explain inequality across various countries, measured by top income shares. The weights come from the genetic or geographic distance between two countries. Income per capita growth is instrumented to find the growth's impact on top income shares first, and then the residuals of the regression are used as instruments for the top income shares to identify the net impact of top income shares on economic growth. Using data of fourteen OECD countries between 1900 and 2009, the estimates provide support to the view that growth reduces top income shares, while top income shares enhance economic growth.

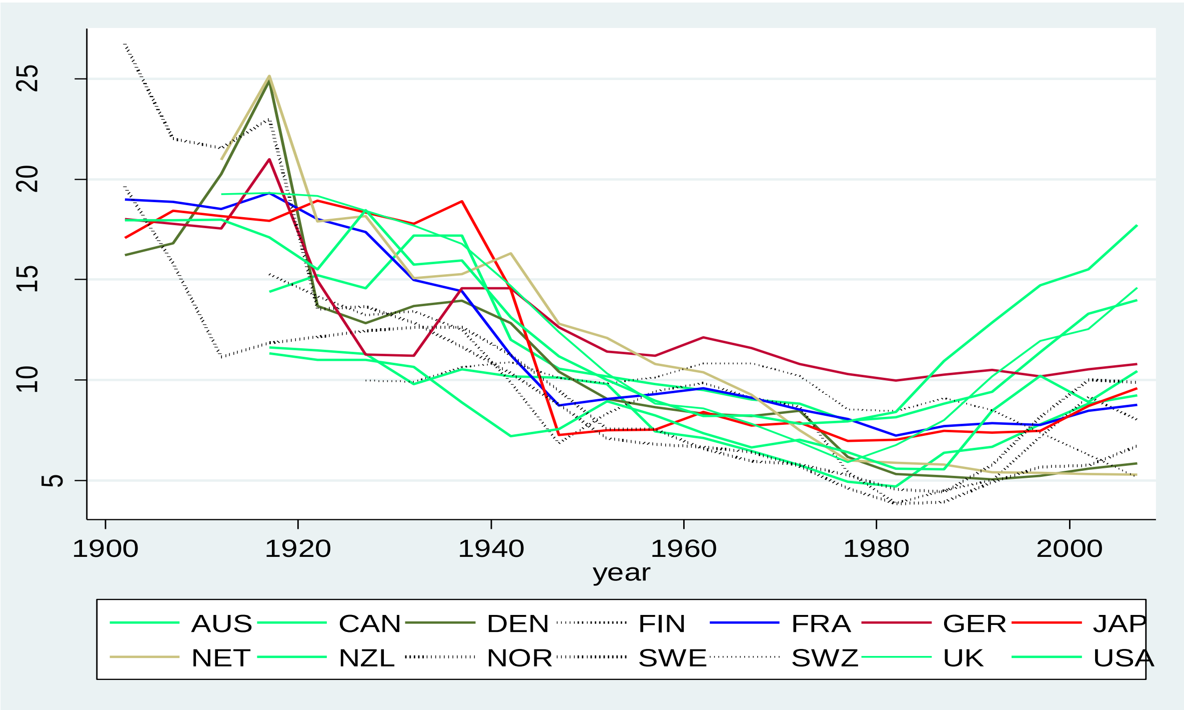
JEL Classification: O11, O15, N10.

Key words: Genetic distance, top income shares, income inequality, growth.

3.1 Introduction

Top income shares have been on the rise since 1980s, especially in the OECD countries (Figure 3.1). The common perception is that the benefits of growth are reaching the rich at the expense of the poor. Interestingly, the number of cross-country studies regarding the relationship between top income shares and economic growth is strikingly low. Neither the impact of growth on top income shares nor the impact the other way around has been widely explored in the literature. This observation begs the question of whether top income shares and economic growth are closely related.

Figure 3.1 Top 1% income shares over time



We find only two published works that address the issue. Roine *et al.* (2009), while identifying the determinants of top income shares, find a positive impact of growth on top 1% income shares and a negative impact on top 2 through 10% income share. The authors use data from India, Argentina and fourteen OECD countries in an unbalanced panel covering the last century. Their primary concern was finding the factors that affect top income shares, not to focus exclusively on the growth-top income relationship. Using first-difference generalized least square technique (FDGLS) and dynamic first-difference (DFD) approach, economic growth and top income relationship was examined while controlling for the trends and time invariant country specific factors in their panel.

On the other hand, Andrews *et al.* (2011) investigate the impact of top income shares on economic growth using data from twelve developed countries between 1905 and 2000. They use lagged levels of GDP per capita and top income variables to address the endogeneity between top income shares and growth. They find that top income shares have no systematic impact on economic growth in the whole sample, although they find a positive impact after the 1960s.

While top income shares are not seen commonly as a measure for inequality[6], there exists a large body of literature that covers the relationship between economic growth and inequality, where inequality is measured by the Gini index and some other variables such as lowest 20% income shares. Despite this, the relationship between income inequality and economic growth remains unclear. For example, while a strand of this literature finds a positive impact of inequality on growth (Li & Zou 1998; Forbes 2000), other finds it to be negative (Perotti 1996; Philippe *et al.* 1999)[7]. Some others find a non-linear relationship. For instance, Banerjee and Duflo (2003) discover growth as an inverted U-shaped function of inequality. On the other hand, Lundberg and Squire (2003) find inequality and growth to be determined jointly by the same set of determinants, proposing the notion that they are the

[6] The main reason is that the cross country comparable data become available after the remarkable work done by Piketty (2001) for France, and subsequently followed by others such as Atkinson (2004), Saez (2005) and Atkinson *et al.* (2011) .

[7] See also Alesina and Rodrik (1994), Bénabou (1996), Benhabib and Rustichini (1996), and Acemoglu and Robinson (2001).

outcomes of the same process. It is also argued that the short run dynamics of the relationship could be different from the long run ones (Kaldor 1955).

The theoretical underpinning of inequality and growth relationship is also unclear as theories provide evidence of both a positive and a negative impact of inequality on growth, depending on the channels through which inequality affects growth. There are multiple channels through which inequality affects growth. The traditional channels advocate that in an unequal society, the rich saves more, and this saving, through productive investment, translates into growth (Kaldor 1957; Bourguignon 1981). On the other hand, the political economy channels advocate that in an unequal society the median voters, as a majority, force the existing regime into redistribution. Redistribution reduces the willingness and efforts of the productive agents, who contributes to economic growth by generating prolific activities continuously (Persson & Tabellini 1994)[8]. Alesina and Perotti (1996) argue that in a highly unequal society, the poor are always dissatisfied, and this dissatisfaction can easily be translated into political instability, which hampers growth. Proponents of the imperfect credit market channel, on the other hand, advocate that some of the productive efforts never sprout due to the lost initiatives by the poorer section of society due to credit constraints (Loury 1981; Rajan & Zingales 2003). Lack of credit actually demotivates the growth-enhancing efforts of the poor, due to lack of opportunity to invest in productive activities, or human capital development (Galor & Zeira 1993).

The effect of growth on inequality is also not clear in the literature. While, for instance, Chambers (2007) and (Lopez 2006) find growth to be a nutrient to inequality, Dollar *et al.* (2013) find it to increase income of the poorest quintile in society. Kuznets (1955), in his seminal paper, finds a nonlinear effect of development on inequality in the long

[8] In a more unequal society the predatory behaviour of a section of poor against the rich threatens the security of property rights thereby reduces growth (Benhabib & Rustichini 1996; Grossman & Kim 1996). In addition, a society committed to equality may foster a wage policy which discourages the entrepreneurship.

run. He finds inequality to rise in the early stages of development as the rich realize the benefits of development first due to their higher ability for entrepreneurship, relatively high level of education, and higher socio-political position, while the poor earn unskilled wages. Over time the poorer section internalizes the benefit of development by gathering more skills, experiences, and education for current and future generations. Eventually the gap between the rich and the poor reduces, thereby producing an inverted U-pattern on the inequality-growth plane.

Chambers (2007) investigates this view empirically, and confirms opposite trends in the short and the long run dynamics. He reports that in the short term, inequality increases while it declines in the long run. As a result, it maintains an inverted U-shaped relationship. On the other hand, Barro (2000), in testing Kuznets hypothesis, does not find any significant effect of inequality on growth in the short run. His findings are rather interesting. He does not find any relationship in the world-wide sample. In the developing countries' sample, however, he finds inequality to be a deterrent to economic growth. In contrast, he finds inequality to foster economic growth in the highly developed countries.

A question ultimately arises of how to disentangle the endogeneity between income inequality and economic growth to derive net one way effect of one on the other. One possible solution could be to find out the impact of one on the other by using instrumental variable regressions rather than using ordinary least square regressions to isolate the one way net effect. In practice, however, it is very difficult to find an instrument that affects economic growth only through the channel of income inequality. However, if one can isolate the feedback effect of growth on inequality first using suitable instrument and, in turn, find the impact of inequality on growth by separating out the feedback effect, then it might work as an effective tool to find the net effect of inequality on growth. Inspired by Brückner (2013), this paper constructs two instruments for economic growth, find the impact of growth on top income shares in two stage least square regressions, and uses the residuals of the second stage regression as instruments for inequality in order to discover the impact of inequality on growth in the subsequent regressions.[9]

Motivated by the influential work of Spolaore and Wacziarg (2009) that genetic distance puts a barrier in the way of the diffusion of development, this work constructs growth spillover through genetic proximity (GSGP) as an instrument for economic growth, using genetic distance between countries as a barrier to growth spill over from one country to another. Spolaore and Wacziarg argue that two populations that are distanced genetically are distanced culturally as well, so that they are less likely to interact with each other and thus unlikely to share development. In contrast, two genetically closer societies share similar traits (genetic and cultural) that help them facilitate growth spill over between them. GSGP refers to the weighted average growth of other countries, which diffuse through the channel of genetic proximity (or nearness), measured by the inverse of the genetic distance between two countries.[10] This work constructs growth spillover through geographical (physical) proximity (GSPP) as the other instrument using geographical proximity in place of genetic proximity. This is grounded on the notion that greater geographical proximity may facilitate the diffusion of growth.

In this work, we run inequality on growth regressions first, and then the other way around. In the first step, the first-stage regressions of per capita GDP growth on the two instruments, GSPP and GSGP deliver economically and statistically significant results,

[9] In investigating the net impact of aid on growth, Brückner (2013) removed the reverse causal effect of growth on aid first by using instruments for growth. Similarly, we isolate the impact of growth on inequality in the first place using instruments, and then remove this effect as a feedback effect to reach the goal of determining the net effect of inequality on growth. The appendix of his paper details the econometric justification of the method.

[10] Genetic distance is a measure of the time elapsed between the populations of the two countries since having their common ancestor. As a result, populations that share more recent common ancestors have had less time to diverge in a range of biological and cultural traits. Cultural traits include beliefs, customs, practices, conventions, etc. that transmit over generations. A more detailed explanation is provided in the appendix.

identifying the proposed models. The second-stage estimates provide evidence that the exogenous component of the variations in growth negatively affects top income shares.

In the second step, in estimating the impact of inequality on growth, the first-stage regressions of top income shares on the residual top income series also deliver statistically significant results. The second-stage estimates provide evidence that top income shares positively affect growth, which supports a traditional view of the inequality-growth relationship, clarifying that a higher saving from top income shareholders and the indivisibility of the investments dictate economic growth. This finding also survives in a battery of robustness checks.

The marginal contribution of this work is that it employs two new instruments for economic growth, which are constructed based on the barrier effect of genetic and geographic distances between countries. It also uses an instrumental variable technique to isolate the impact of inequality on growth which, so far as we are aware, is not practiced in the panel setting due to the unavailability of instruments for inequality. The results of this study will also contribute to the recent debate surrounding Thomas Piketty's (2014) famous book "Capital in the Twenty-First Century", which portrays a dreadful picture of the coming days, where income will be accumulated in the hands of a few rich elites, if we cannot keep the rate of economic growth up above the return to capital.

We use data from 1900 to 2009 in a panel of fourteen OECD countries[11] for which top income shares are available for most of the period.[12] We use the five-year average of the data starting from 1900 to overcome business cycle fluctuations and provide a foundation to discuss the long run inequality-growth relationship. The averaging of years also reduces serial correlations in the standard errors at the cost of variability reduction.

[11] Countries in the sample include: Australia, Canada, Denmark, Finland, France, Germany, Japan, the Netherlands, New Zealand, Norway, Sweden, Switzerland, the UK and the USA.

[12] But still the panel is unbalanced as there are some missing values of top income data between 1900 and 2009. For instance, top income data for Switzerland is available only between 1933 and 1995.

Our results survive once the sample is trimmed down to between 1900 and1979. However, they do not survive for samples beyond 1960. The findings are consistent with Forbes (2000), and the richer country sample of Barro (2000) in that inequality positively contributes to economic growth. Unlike Roine *et al.* (2009), who find both positive and negative impact of growth on top income shares, our results consistently indicate a negative impact of growth on various measures of top income shares. On the other hand, we find a systematic positve impact of top income shares on economic growth in the whole of last century, although Andrews et al. find it only after the 1950s.

Methodologically, this work is built upon the contribution of Brückner (2013), who exercises a technique of separating out the reverse causal effect of dependent variable on the main explanatory variable. The rest of the paper proceeds as follows: Section 2 describes the empirical strategy, section 3 instruments, section 4 data, and section 5 reports the results along with few robustness checks. Section 6 concludes finally.

3.2 Empirical strategy

This work investigates the impact of top income shares on economic growth. The main specification for growth equation is as follows:

$$Growth_{it} = \propto_i + \gamma_t + \beta Top_{it} + \delta' CV_{it} + \varepsilon_{it} \quad (1)$$

where $Growth$ refers to per capita GDP growth and Top refers to the top income shares, a measure of income inequality. β is the parameter of interest. Its value is expected to be positive based on the traditional view that inequality enhances economic growth mainly through indivisibility of savings and investment, facilitated by the rich in a semi-open economy. CV refers to a vector of control variables, and ε is the error term.

The control variables we account for in the growth equation are standard in the literature, and are chosen from among the control variables included in the influential works of Barro (2000), Forbes (2000), and Perotti (1996). They include capital-output ratio, educational attainment, private credit, average tariff rate, and number of domestic patent applications. Initial GDP per capita (*IGDPpc*) is also included, as it is indeed important to control for the income per capita to address the catching up effect of income across the economies. Due to unavailability of trade openness data for the whole of the last century, we use the average tariff rate (tariff/import in a period) as a proxy for openness.

Financial development can often be pro-rich as the rich have the ability to pay collaterals, which is a prerequiste to get credit from financial institutions. Moreover, they have a longer history of credit repayments, and have social and political connections that help them to internalize the benefits of financial development. Therefore it is plausible that financial development can increase the top income shares.[13] Technological development may also be biased to the rich, as the rich are able to derive the benefits of technological development iinitially, and also in the long run, a benefit the poor lack. On the other hand, it is plausible that top marginal tax rates would have a negative impact on top income shares, as progressive taxation may reduce the incentive of the rich to take productive entrepreneurship. Higher intial GDP per capita increases the likelihood of rise in income redistribution through taxation. Therefore, we can expect a negative impact of initial GDP per capita on top income shares.

As discussed earlier, endogeneity entangles the relationship between inequality and growth, and it is difficult to separate one's influence from the other. Therefore, in eq. (1), it is hard to measure the true impact of inequality on growth, because Top and ε seem to be

[13] Opposite view also exists in world-wide sample. For instance, Beck *et al.* (2007) using data of 72 developed and developing countries claim that financial development is pro-poor.

highly correlated. Since income inequality is endogenous to growth, we estimate β using instrumental variable estimators. The instrument for inequality (*Top*) comes form the residuals of the following regression that captures the feedback effect of growth on inequality in eq. (1).[14]

$$Top_{it} = a_i + \mu_t + \theta Growth_{it} + \varphi IGDPpc_{it} + e_{it} \quad (2)$$

In eq. (2), θ is measured by using two instruments, GSPP and GSGP, both of which affect top income shares only through the channel of economic growth. Measuring θ from eq. (2) is necessary to isolate the feedback effect of growth on top income shares in equation (1).

The following rearrangement of eq. (2) provides the residual series of top income shares to instrument *Top* in eq. (1) and estimate the net effect of top income shares on growth.

$$Top\_resid_{it} = Top_{it} - \theta Growth_{it} \quad (3)$$

3.3 Growth Spillover instruments: GSGP and GSPP

A growing body of literature records the importance of spillover of growth between countries in explaining economic growth (Ang & Madsen 2013; Ho *et al.* 2013). One country's growth can create new import demand, outflow surplus capital and technology spill over to another country and thereby may enhance the productivity and growth of that country. The factor productivity of one country may also spill over to another country as much as technology, when technological products cross borders toward destinations abroad (Coe & Helpman 1997; Guellec & Van Pottelsberghe De La Potterie 2004; Madsen 2007).

Using 26 OECD countries data between 1971 and 2005 in a spatial dynamic panel data model, Ho *et al.* (2013) examine how bilateral trade contributes to the international spillover of economic growth. Extending the Solow growth model with spatial autoregressive

[14] Based on the technique applied by Brückner (2013)

terms, they find a significant positive spillover of growth from countries to their trading partners.

On the other hand, Ang and Madsen (2013) investigate possible channels through which foreign knowledge crosses border to boost the total factor productivity of a country. They emphasize the importance of various trade and non-trade channels such as exports, imports, technologies embodied in the trade flows, FDIs, and geographical distances in explaining total factor productivity growth of six Southeast Asian miracle economies connected through international trade with 20 OECD countries between 1955 and 2006.

Although the importance of spatial effects on growth through various trade and nontrade channels has been noted by many scholars, the literature encompassing genetic distance of populations across countries in explaining spill over of economic development is scant. Spolaore and Wacziarg (2009) argue that genetic and cultural traits transmit mainly vertically between generations in the same genetic groups. They also argue that the genetic distance of population, which is the elapsed time since the population of two countries had a common ancestor, may prevent the diffusion of development, as genetic and cultural traits cause strong inertia in horizontal transmission across genetically dissimilar population.

Spolaore and Wacziarg (2013) elaborates the idea and contend that genetic proximity, or a genealogical link between the populations of two countries may facilitate contemporaneous transmission of growth. Guiso *et al.* (2009) explore the importance of cultural exchange, which is easy between two genetically similar populations that engage in trade. They find that genetic similarity increases bilateral trust, which facilitates trades. Giuliano *et al.* (2014) argue that genetic and geographical proximities across the populations are expediters to trade.

Thus country pairs with greater genetic proximity are more likely to trade, and thereby accelerate any growth spill over between them. In having the same or similar inherited deeply-rooted factors such as genes or cultures, they may possess similar tastes and preferences, and also adopt the technology of their closer counterparts quicker, make a favourable environment for bilateral trade that expedites growth.

Based on Cavalli-Sforza *et al.* (1994), Spolaore and Wacziarg (2009) compile a dataset for country pairs in explaining the genealogical link between countries. Because a country may comprise of a heterogeneous population from various genetic backgrounds, the authors measured the weighted average allelic frequency of the population using population segments from different ancestral roots as weights. They compile country-pair data that offers the expected genetic distance of two individuals chosen randomly from two countries.[15]

This work constructs an instrument for growth called Growth Spillover through Genetic Proximity (GSGP), that refers to the weighted average growth of other countries using genetic proximity between a country and its trading partners from Spolaore and Wacziarg (2009) dataset. The construction of the instrument is based on the simple idea that the diffusion of growth is more likely when two countries are in greater genetic proximity (or smaller genetic distance) and share more common genetic and cultural traits.[16]

Based on the same idea, we construct growth spill over through geographical distance (GSPP) that uses the physically shortest distance between the capital cities of a country pair.[17] The first and foremost argument in favour of geographical distance as a barrier to the spill over of growth is that distance increases the transaction cost. Based on the augmented Solow model by Mankiw *et al.* (1992), Boulhol *et al.* (2008) uses the idea of geographical

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[15] It is worth mentioning that this data excludes the genetic influence that relates to the phenotypic variation, which directly affects survival and fitness. Rather, the data includes only the selectively neutral allele frequency of a population group that is free from phenotypic changes through selective pressure that are, as suggested by Darwin, appropriate for the reconstruction of evolutionary history.

[16] Spolaore and Wacziarg (2013) tested the idea in a unified empirical framework that explains both the current population in a country-pair and their ancestral composition in 1500 has a significant positive effect of genetic distance on income difference, using both simple weighted genetic distance, and genetic distance to the frontier through the current match.

[17] The use of geographical distance is not new. Started with the gravity model for trade, the distance between two countries has been used as a barrier against trade in many subsequent works.

proximity between two countries to have a favourable impact on the productivity of counterparts through product and labour market channels. Distance to major markets, captured by proximity, plays an influential role in determining the growth per capita of a country, as proximity ensures easy access to nearby larger markets, reinforces competition between producers, and encourages innovation and efficiency in the use of resources. Two large markets can also cooperate easily to reap the benefit of economies of scale. Therefore, geographic proximity, measured as the inverse of geographical distance, can play a vital role in effectively reducing the transaction cost of international trade.[18]

The idea of GSPP and GSGP is that country *i'*s growth is influenced by the growth of country *j*, and the nearer the country *j* is to country *i*, either genetically or geographically, the higher the possibility of influence on country *i'*s growth.

Suppose country *j* is at a distance of d_j (d_j= genetic or geogrphical distance) from country *i*. Then inverse of distance ($1/d_j$) captures the nearness or the proximity of the country *j* from country *i*. The nearer the country *j* is, the more influence it's growth has on country *i'*s growth, as it may reduce the transaction cost of diffusion of growth. The expression can be written as follows:

$$IV_{it} = \frac{\sum_1^{n-1}(1/d_j) * Growth_{jt}}{\sum_1^{n-1}(1/d_j)}, \quad (j \neq i) \tag{4}$$

where, *IV=GSPP or GSGP*, depending on d_j. Inverse distance (1/distance, or $1/d_j$) is used as a weight and quantifies how nearer country *j* is to country *i* in terms of genetic or geographical distance.

[18] However, two nearby markets producing similar goods or services with similar comparative advantage can also affect growth of the counterpart negatively by competing to capture the same foreign market.

In this work, we use genetic and geographical proximity pairs for 19 countries in constructing instruments for all of them on the assumption that growth spills over mainly among these OECD countries[19]. However, the results and analysis is restricted to fourteen countries mainly because of their availability of century long top income shares data.

3.4 Data and measures

Top income data from the *World Top Income Database* (WTID) of the *Paris School of Economics* provides a greater opportunity to look into the realtionship between income inequality and economic growth in the long run. While we can not go beyond the 1950s using the conventional income inequality measures such as the Gini index, top income data increases our range and allow us to research back over the whole of the twentieth century (Roine *et al.* 2009). Before-tax top income data for fourteen OECD countries that are drawn on from the tax databases of the countries concerned has been used. Top income data as a measure of inequality allows to explore how economic growth affects the income distribution in the top strata of income, and vice versa. Consequently, the use of top income data has an advantage in that it does not require generalization of the inequality-growth relationship for the whole income distribution. However, it removes the ability to analyse what happens to the rest of the distribution of income. Other broad measures of inequalities such as the Gini index also have limitations, as they cannot distinguish between inequality in the top and bottom of the distribution and also cannot be discussed for the whole of the twentieth century due to lack of data.[20]

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[19] The countries are Austria, Belgium, Spain, Italy, and Portugal, in addition to the 14 OECD countries in our inequality-growth analysis.

[20] It is possible that distribution is different in different locations of the distribution. Voitchovsky (2005), for example, finds that inequality positively affects growth above the median income, while it is opposite below the median income.

We use a five-year average of each country's data since 1900. The year-averaging reduced the missing data problem to a great extent as we average only the available data points within each five year span. The variability of data has been compromised by this method but avoids the impact of business cycle fluctuations on the variables.

Figure 3.2 Top 1% income shares and economic growth

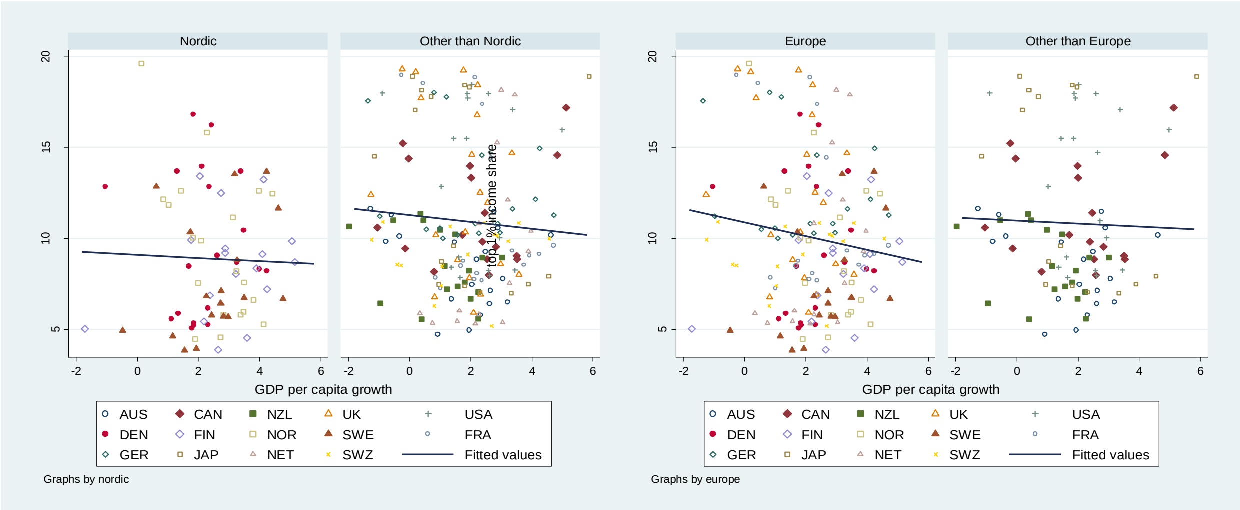

Figure 3.2 shows the variation of top 1% income shares with economic growth in broadly characterised countries, namely (a) Nordic versus non-Nordic Countries, and (b) European versus non-European countries. Nordic countries are regarded as high redistribution countries along with high marginal tax rates. On the other hand, we want to be sure that the European countries opposed to their non-European counterparts are not driving out our tests. In all the groups the association between the top 1% income shares and growth seems to be negative, however, for Europe the relationship seems to be more negative. As the relationship between top income shares and economic growth suffers from a severe endogeneity problem, it is difficult to conclude anything about the relationship based only on Figure 3.2. The instrumental variable regression results in the next section will provide more specific inferences.

Throughout the paper, top 1% income shares (*Top1*) is used as the primary measure of income inequality that captures the income share of the top 1% of income holders in an economy. To check the robustness of the results, other top income measures such as the top 10%, top 5%, top 0.5%, and top 0.1% are also used. We use growth data from the Maddison Project Database that provides an extension of the data of Maddison (2003) up to recent years.

For each of the top income measures, the instrument for Top in eq. (1) is measured using the *Top_resid* series derived by using eq. (3). The *Top_resid* series captures the variation of top income shares netting off the effect of growth on it. We use private credit as percentage of GDP, average years of educational attainment, average tariff rate, capital-output ratio, and number of domestic patent applications as control variables in estimating eq. (1) along with GDP per capita. Controlling for these variables is important since all of them may have a relationship with both top income and growth. For example, in an imperfect capital market the rich endowed with better social and political connections may gain a greater benefit of financial development than the poor (Rajan & Zingales 2003). On the other hand, educational attainment is generally explained to be a source for inequality reduction, as public education may narrow down the gap between rich and the poor (Barro 2000). There is a mixed explanation of openness and technology in that they may increase or decrease inequality based on the level of economic development. On the other hand, it is standard practice to use GDP per capita in the growth equation as income converges across the countries over time due to the diminishing returns of capital and other resources.

Description of the variables and the data sources are provided in Table 3.A1, and the summary statistics and correlation coefficients of the key variables are presented in Tables 3.A2 and 3.A3 in the appendix.

3.5 Results

3.5.1 Effect of growth on top 1% income shares

Panel A of Table 3.1 reports the results of the basic model in equation (2) that measures the effect of economic growth on top 1% income shares. Column (1) reports the univariate least square regression results, where growth has a highly significant negative impact on top 1% income shares. The results show that economic growth reduces inequality by decreasing top income shares. However, we cannot rely on the results, as the univariate regression only explains 2.4% of the variations in the dependent variable.

Table 3.1 Effect of growth on top 1% income shares

Dep. variable: Top1% income shares	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Panel A: OLS and 2SLS results (measuring eq. (2))				
			IV regressions: Instrumenting growth using GSPP & GSGP				
	OLS regression	OLS regression	GSPP	GSGP	GSPP+ GSGP	GSGP	GSPP
Growth	-0.227*** (0.075)	-0.223*** (0.079)	-0.918*** (0.190)	-0.909*** (0.228)	-0.919*** (0.190)	-1.33 (6.774)	-0.939*** (0.340)
GSPP						0.259 (4.261)	
GSGP							0.014 (0.195)
Initial GDP per capita		-3.810*** (0.329)	-4.068*** (0.318)	-4.069*** (0.317)	-4.068*** (0.318)	-4.066*** (0.390)	-4.066*** (0.322)
Sargan test chi2 p-values					**0.933**		
Observations	287	287	287	287	287	287	287
R^2	0.024	0.426					
			Panel B: First stage regressions				
GSPP			0.626*** (0.090)		0.663*** (0.169)	0.663*** (0.169)	0.663*** (0.169)
GSGP				0.473*** (0.085)	-0.037 (0.154)	-0.037 (0.154)	-0.037 (0.154)
Initial GDP per capita			0.003 (0.241)	0.089 (0.247)	0.0004 (0.242)	0.0004 (0.242)	0.0004 (0.242)
First stage F-stat (excluded IV)			48	31.2	24.1	0.06	15.3
First stage R^2			0.152	0.105	0.153	0.153	0.153
First stage partial R^2 (excluded IV)			0.151	0.103	0.151	0.0002	0.054
Country FE			Yes	Yes	Yes	Yes	Yes

Notes: Growth is instrumented using the followings: growth spillover through geographical distance (GSPP) and growth spillover through genetic distance (GSGP). Robust standard errors are in the parentheses. We use ***, **, and * to refer 1%, 5%, and 10% significance level. The constants are not reported for any of the regressions.

In explaining income inequality, it is indeed important to include the initial income level as it determines the level of development in a society, which ultimately determines how the benefit of growth will be redistributed in a society. For instance, Sigelman and Simpson (1977) argue that, unlike the poorer countries, in rich economies low income earners are more patient because more surplus remains available for redistribution among them. Therefore, we include initial GDP per capita in the regression in Column (2). The results show that inclusion of GDP per capita raises the explanatory power of the regressants to 42.6%, compared to only 2.4% in column (1).

Coulmn (3) to (7) report the impact of growth on top 1% income shares, based on instrumental variable regressions. The regression results throughout column (3) to (5) in panel A show a highly significant negative impact of growth on top 1% income shares. The magnitude seems to be much higher throughout all the instrumental variable regressions in column (3), (4) and (5), in comparison with the OLS results in column (1) and (2). In column (3) and (4), growth spillover through geographical proximity (GSPP) and growth spillover through genetic proximity (GSGP) are used as instruments for growth, respectively, and in column (5) the instrumnts are combined together. The coefficients of growth seem to be largely the same using any of the instruments, or combination thereof, which explains the instruments GSPP and GSGP to be quite strong in explaining the impact of growth on top 1% income shares. In addition, the chi-square *p*-value (0.933) of the Sargan statistic in column (5) provides strong support regarding the overidentification of the basic bivariate model.

In column (6) growth is instrmented by GSGP while GSPP is included as an explanatory variable. In contrast, in column (7), GSPP is used as an instrument for growth and GSGP is included as an explanatory variable. Inclusion of GSPP and GSGP, in column (6) and column (7), respectively, as right hand side (RHS) variables put forward a simple exclusion restriction strategy that further tests the identification of the basic model. This is based on the premise that once the variation of the dependent variable is captured through instrumentation, an instrument included as a control variable cannot have any significant impact on the dependent variable, i.e., it only works through the main explanatory variable (See Acemoglu *et al.* (2001), for a detailed description). The insignificance of the coefficient measures of GSPP and GSGP in column (6) and column (7) thereby extends additional support to the validity of the basic model in equation (2).

Column (3) to (7) in panel B reports the first stage regression results of the instrumental variable regressions in panel A, where GDP per capita growth is the dependent variable that is regressed against initial income level and the relevant instruments. As income converges across the countries, it is indeed important to include income level in any growth regression. The coefficient of initial GDP per capita is not significant in any of the regressions. It indicates that the impact of GDP per capita works on growth only through the channel of the instruments for growth. The coefficients of GSPP are significant at the 1% level throughout all the first stage results and GSGP is also significant at the 1% level when it is used alone as an instrument for growth (column (4)), underlining the vailidity of the used instruments. The first stage R^2 and partial-R^2 values along with a high chi-square *p* value of the Sargan statistic (0.933) in column (5) provides a strong support for the basic bivariate model. Moreover, the first-stage F-statistics (24.1) in column (5) is significantly higher than the rule-of-thumb of 10 proposed by Staiger and Stock (1997), providing confidence that the instruments are strong and valid. The bivariate model in column (5) is therefore considered as the benchmark model for the subsequent analysis in section *4.2*, *4.3*, and *4.4.* It reports that a one percentage point change in GDP per capita growth reduces top 1% income shares by 0.919 of a percentage point.

3.5.2 Effect of top 1% income shares on growth

Table 3.2 reports the effect of top 1% income shares on per capita GDP growth. Column 1 reports ordinary least square results, where country and time fixed effects are captured through dummies. The impact of top 1% income shares on growth seem to be insignificant and negative. Column (2) to (8) report the instrumental variable regression results. The impact of top income shares on growth turns highly significantly positive. The possible reason might be that in the OLS regression, causality between growth and inequality works in both ways so that the net outcome (coefficient=-0.053) is found to be insignificantly negative. However, once the substantial negative effect of growth on top income share is removed by instrumental variable regressions, the net one way effect of top income on growth becomes positive.

Table 3.2 Effects of top 1% income shares on GDP per capita growth

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV	(6) IV	(7) IV	(8) IV
	Panel A: OLS and Second-stage results (*Dep.Var.=Growth*)							
Top 1% income shares	**-0.053**	**1.20*****	**1.19*****	**1.31*****	**1.16*****	**1.20*****	**1.17*****	**1.21*****
	(0.076)	**(0.153)**	**(0.152)**	**(0.169)**	**(0.149)**	**(0.152)**	**(0.152)**	**(0.089)**
Initial GDP per capita		-1.626	-2.050	-0.868	-3.23***	-1.633	-1.661	-3.63***
		(1.252)	(1.340)	(1.318)	(1.487)	(1.256)	(1.239)	(1.597)
Educational attainment			1.452					0.512
			(1.715)					(1.896)
Privatecredit as % of GDP				-2.09***				-1.96***
				(0.745)				(0.733)
Patent applications domestic					1.055*			1.69**
					(0.562)			(0.702)
Average tariff rate						0.017		-0.156
						(0.267)		(0.306)
Capital-output ratio (logs)							-0.804	-1.33
							(0.906)	(1.013)
Observations	286	286	286	286	286	286	286	286
Number of countries	14	14	14	14	14	14	14	14
	Panel B: First-stage results (*Dep.Var.=Top 1% icome shares*)							
Top_resid		0.530***	0.532***	0.507***	0.537***	0.530***	0.535***	0.527***
		(0.071)	(0.072)	(0.071)	(0.071)	(0.071)	(0.072)	(0.072)
First stage F statistics		253	253	225	258	251	249	222
First stage R^2	**0.217[a]**	0.878	0.878	0.882	0.879	0.878	0.878	0.885
First stage partial R^2 (excluded IV)		0.505	0.505	0.476	0.510	0.503	0.502	0.475
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: R^2 =0.217[a] for the OLS regression in column (1). Residual series of top1% income share, as per the specification in equation (3), has been used to instrument top1% income shares throughout all the IV regressions. We use ***, **, and * to refer 1%, 5%, and 10% significance level. Constants are not reported in the regressions. In panel B, only *Top_resid* is reported, for brevity.

Throughout columns (2) to (8), the residual series of top 1% income shares (*Top_resid*) is used as an instrument for top income shares, based on the technique discussed in section 2. Therefore, once the the coefficient of growth in equation (2) is quantified (0.919), we get *Top_resid* as follows using eq. (3).

$$Top\_resid_{it} = Top_{it} + 0.919 * Growth_{it} \quad (5)$$

Top_resid is used as an instrument to capture the variation of exogenous component of per capita GDP growth that is only associated with the variation in top 1% income shares.

Throughout columns (3) to (8), initial GDP per capita growth is controlled for all the regressions. Considering the income convergence hypothesis, controling for initial income level is uncontroversial in explaining various determinants of growth. Column (2) in panel A, reports baseline results of the impact of top income shares and initial GDP per capita on growth. The results report that a one percentage point change in top 1% income shares is associated with an increase in growth by 1.2 percentage point in this bivariate regression.

In column (3) to column (7), other control variables are included only one at a time, and in column (8) all the control variables are combined together. Column (8) produces the benchmark results of the impact of top 1% income shares on economic growth. Top 1% income shares seem to respond to a 1 percentage point inccrease GDP per capita growth by 1.2 percentage points. The results show that top 1% income shares has a highly significant positive impact on growth irrespective of the control variables used.

3.5.3 Robustness check using alternative samples

Table 3.3 presents the estimates of the relationship between top income shares and GDP per capita growth for different subsamples. Column (1) and (2) compares the estimates between the Nordic and the non-Nordic countries, while Column (3) and (4) compares the same for the European and the non-European countries, respectively. Column (5) displays the results for the before 1979 sample of all fourteen countries, to capture the impact of the break in around 1980 as depicted in Figure 3.1. The results are largely the same, irrespective of the variation in the sample, and in comparison with the benchmark results in Column (5) of Table 3.1.[21]

Table 3.3 Robustness check using alternative samples

	(1) Nordic countries	(2) Other than Nordic	(3) European countries	(4) Other than European	(5) All countries (1900-1979)
	Panel A: Effect growth on top 1% income shares (estimation of eq. (2))				
Growth	-0.983***	-0.876***	-0.758***	-0.475**	-0.741***
	(0.289)	(0.235)	(0.194)	(0.223)	(0.191)
Observations	85	201	186	100	202
Number of countries	4	10	9	5	14
Sargan chi2 p-values	0.422	0.642	0.086	0.003	0.222
First stage F-stat (excluded IV)	32.4	12.4	18.7	12.6	14.1
First stage R2	0.459	0.117	0.178	0.219	0.149
First stage partial R2 (excluded IV)	0.454	0.116	0.177	0.216	0.132
	Panel B: Effect of top 1% income shares on growth (estimation of eq. (1) using all controls)				
Top 1% income shares	0.297***	1.502***	1.148***	0.998***	1.737***
	(0.094)	(0.229)	(0.179)	(0.1787)	(0.273)
Observations	85	201	186	100	202
Number of countries	4	10	9	5	14
First stage F-stat (excluded IV)	202	131	162	123	113
First stage R^2	0.978	0.858	0.922	0.946	0.877
First stage partial R^2 (excluded IV)	0.792	0.447	0.522	0.648	0.405

Notes: Country and time fixed effects are considered in all the regressions in panel B. The control variables are not reported for brevity in both panels. In panel A, both GSGP and GSPP are combined to instrument growth. We use residual series of top income shares to instrument respective top income shares in panel B. ***, **, and * refer to 1%, 5%, and 10% significance level.

Panel B reports the estimates for the same subsamples of the impact of top 1% income shares on GDP per capita growth, where growth has been instrumented by *Top_resid* , the residual series produced for each subsample using eq. (3). Based on the coefficients of

[21] The after 1980 sample does not provide any significant relationship between growth and top 1% income shares, and hence, the results are not reported in Table 3.3. Similarly, results for after 1960 sample also are not reported in Table 3.3, as they do not provide any significant linear relationship between growth and top 1% income shares.

growth generated in panel A, the equations for the calculation of *Top_resid* for different subsamples are shown in the following five equations.

Nordic sample: $$Top\_resid_{it} = Top_{it} + 0.983 * Growth_{it} \quad (6)$$

Other than Nordic sample: $$Top\_resid_{it} = Top_{it} + 0.876 * Growth_{it} \quad (7)$$

European sample: $$Top\_resid_{it} = Top_{it} + 0.758 * Growth_{it} \quad (8)$$

Other than European sample: $$Top\_resid_{it} = Top_{it} + 0.475 * Growth_{it} \quad (9)$$

1900-1979 sample: $$Top\_resid_{it} = Top_{it} + 0.741 * Growth_{it} \quad (10)$$

The results reported in panel B show that, irrespective of the subsamples, top 1% income shares have a highly significant positive impact on growth. The results are directly comparable with the benchmark results of column (8) in Table 3.3, because all the control variables that were used in the benchmark regression for the whole sample are also used for the subsamples in measureing eq. (1). Again, irrespective of the subsample used, the results are very much similar to the benchmark results reported in Table 3. The first stage F-statisitics and partial R^2 for the excluded instrument are quite high to support the claim in favor of the reported regression results. The control variables are not reported for the sake of brevity. Country and time fixed effects are considered in all the regressions.

3.5.4 Robustness check using alternative measures of top income shares

The above findings are based on an underlying assumption that top income shares positively affect economic growth. However, till only top 1% income shares have been used as the main explanatory variable. Panel A in table 3.4 produces the estimates of the effect of growth on various top income shares (other than top 1% income share) as measured by equation (2). The instrumental variable regrssion results of the effect of growth on each of the top income shares using GSGP and GSPP together as instruments for growth are reported.

Irrespective of the top income shares group used, growth seems to have a negative impact on the top income shares that are significant at the 1% level. Moving toward the richer income groups, the results show that the impact of growth gradually becomes smaller in magnitude, implying that income shares of richer income groups are less sensitive to growth.

Table 3.4 Robustness check using alternative measures of top income shares

	(1) Top 10%	(2) Top 5%	(3) Top 0.5%	(4) Top 0.1%
	Panel A: Effect growth on top 1% income shares (estimation of eq. (2))			
Growth	-1.056***	-1.064***	-0.793***	-0.551***
	(0.263)	(0.225)	(0.178)	(0.123)
Observations	234	308	264	264
Number of countries	11	14	12	12
Sargan chi2 p-values	0.322	0.996	0.661	0.752
First stage F-stat (excluded IV)	21.6	26.8	20. 1	20.1
First stage R^2	0.164	0.155	0.140	0.140
First stage partial R^2 (excluded IV)	0.164	0.158	0.139	0.139
	Panel B: Effect of top income shares on growth (estimation of eq. (1) using all controls)			
Top income shares	0.755***	0.851***	1.664***	2.389***
	(0.123)	(0.120)	(0.245)	(0.346)
Observations	234	308	264	264
Number of countries	11	14	12	12
First stage F-stat (excluded IV)	185	217	138	143
First stage R^2	0.807	0.792	0.782	0.753
First stage partial R^2 (excluded IV)	0.462	0.431	0.360	0.370

Notes: Country and time fixed effects are considered in all the regressions in panel B. The control variables are not reported for brevity in both panels. In panel A, both GSGP and GSPP are combined to instrument growth. We use residual series of top income shares to instrument respective top income shares in panel B. ***, **, and * refer to 1%, 5%, and 10% significance level.

On the other hand, panel B displays the impact of various top income shares on growth. Equation (1) has been measured using instruments for the top income shares. The instruments are as usual derived using residual series of each top income shares group. The impact of various top income shares on growth are positive and highly significant. Moving toward richer groups from column 1 toward column 4 shows increasing magnitudes of the coefficient estimates. The results suggest that small richer top income groups contribute more to growth, which highlights the importance of the indivisibility of investment that richer groups can conveniently afford, compared to their counterparts in an imperfect capital market.

4.5 A further analysis of the effect of growth on top 1% income shares

The analysis of the impact of growth on top income shares in all the above discussions are based on the model in eq. (2), which considers only initial GDP per capita as a control variable. In this section, the basic model in eq. (2) is estimated with additional control variables to check if there is any remarkable change in the results.

Table 3.5 Effect of growth on top 1% income shares-a further analysis

Dep. Var: top 1% income shares	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP per capita growth	-0.92***	-0.58***	-0.96***	-0.89***	-0.94***	-0.63***	-0.65***	-0.54***
	(0.195)	(0.150)	(0.199)	(0.187)	(0.200)	(0.179)	(0.167)	(0.168)
Educational attainment	0.121						-2.617*	-7.42***
	(1.706)						(1.481)	(2.268)
Private credit		3.271***					3.313***	2.677***
		(0.403)					(0.458)	(0.648)
Domestic patent application			0.713				1.27***	2.39***
			(0.515)				(0.476)	(0.567)
Average tariff rate				-0.382*			-0.380*	-0.478
				(0.208)			(0.198)	(0.220)
Capital share in GDP (%)					0.067**		0.076***	0.103*
					(0.030)		(0.024)	(0.055)
Top marginal tax rate						-3.06***		-1.202*
						(0.514		(0.600)
Intial GDP per capita	-4.11***	-5.73***	-4.44***	-4.56***	-3.68***	-3.37***	-5.83***	-4.85***
	(0.609)	(0.326)	(0.421)	(0.414)	(0.351)	(0.401)	(0.586)	(0.822)
Observations	286	286	286	286	267	191	267	173
Number of wdicode	14	14	14	14	13	11	13	10
Sargan chi2 p-value	0.93	0.95	0.98	0.84	0.83	0.09	0.96	0.05
First stage F stat	22.8	22.7	22.4	23.6	21.6	21.2	18.4	17.2
First stage R2	0.157	0.153	0.158	0.153	0.156	0.215	0.164	0.221
First stage partial R2	0.145	0.145	0.143	0.150	0.147	0.197	0.130	0.182

Notes: Except top 1% income shares, GDP per capita growth and capital share in GDP, all the other varibles are in logarithms. Growth is instrumented using the followings: growth spillover through geographical distance (GSPP) and growth spillover through genetic distance (GSGP). Robust standard errors are in the parentheses. ***, **, and * refer to 1%, 5%, and 10% significance level. The constants are not reported for any of the regressions.

Table 6 presents the impact of growth on top 1% income shares with a set of additional control variables added to the model in eq. (2). All the results (the impact of growth on top 1% income shares) are significant at 1%, and seems to be largely the same, using control variables each at one time throughout columns (1) to (8). In column (7) all the control variables except the top marginal tax rates are accounted for. In column (8) top marginal tax rates are also included. The impact of growth is highly significantly negative on top 1% income shares, irrespective of the control variables used. Technological development, private credit and capital share in GDP seem to have positive impact, while initial GDP per capita, top marginal tax rates, and educational attainment seem to have negative impact on top income shares. Analysis in this section further reinforces that economic growth, when looking into a century long panel, has a negative impact on top income shares, irrespective of the control variables used.

Capital share in GDP shows a positive impact on top income shares, while top marginal tax rates show negative impact. The findings are consistent with Piketty (2014), who provide a frightful picture of coming decades, where capital income will be accumulated in the hands of the rich. Our study finds a negative impact of top marginal tax rates on top 1% income shares between 1 to 10% significance level. Although an extensive examination of the impact of progrssive tax rates on top income shares is beyond the scope of our work, it could be a next step for future work, as top marginal tax rates are widely used as a tool to control rises in top income shares. Piketty also suggests progressive taxation as a remedy of widening income gaps. New projects in this direction would be able to answer a crucial question of how effective prograssive tax rates are in narrowing down income gap in societies.

3.6 Conclusions

There is still no consensus in the literature about how inequality and growth affect each other. This work revisits this old but unresolved issue employing two new instruments for growth and using top income shares as a measure of inequality in a panel of fourteen OECD countries. The instruments are constructed based on the simple idea that growth of one country is influenced by others as long as they are connected to each other through international trade and other exchanges. The distance between two countries, either genetic or geographic, hinders the spilling over of growth between them. The instrumental variable regressions show a highly significant negative impact of growth on top income shares, which is consistent with the finding that growth in general reduces income inequality in the long run.

This work analyses growth and inequality relationship in both the directions: from growth to inequality, and from inequality to growth, employing two-stage least square regressions. The work finds that income inequality measured by top income shares enhances economic growth, although growth reduces top income shares. As a result, causality running from growth to inequality and from inequality to growth may balance each other. For instance, the benchmark result find a 0.9 percentage point decrease in top 1% income shares due to a one percentage point increase in growth. In turn, a one percentage point drop in top 1% income shares decreases growth by 1.2 percentage points. Consequently, they neutralize each other, at least partially. The results that top income shareholders significantly contribute into the economic growth are consistent with the findings of Barro (2000) in richer country sample.

The work has another interesting finding in that the impact of growth on top income shares is smaller in higher income groups. On the other hand, a higher contribution in growth comes from the small richer portion of the society.

This work reinforces the argument put forward by Piketty (2014) in his influential book “Capital in the Twenty-First Century” that top income shares go up due to increase in capital shares in income. It also confirms that the impacts of economic growth and capital share on top income shares work in the opposite directions. While capital share in income raises top income shares, growth reduces it. However, this work does not explore to what extent they neutralize each other, as it is beyond the scope of the study. Future works can be developed in that direction. They may also investigate the impact of progressive marginal tax rates on the top income shares as it is a widely used tool to control the rise in top income shares.

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Appendix

Table 3.A1 Description of variables and data sources

Variable	Description	Source
Top income shares	Data are downloaded from World Top Income Database of Paris School of Economics. They are derived from the tax returns of countries. They are before tax data and are in % share.	*World Top Income Database* of *Paris School of Economics*
GDP per capita	Per capita real GDP in 1990 International Geary-Khamis dollars, from Maddison Project Database.	http://www.ggdc.net
GDP per capita growth	Derived from per capita GDP in 1990 International Geary-Khamis dollars, from Maddison Project Database.	http://www.ggdc.net
Geographical distance	The shortest distance between the two capital cities in kilometres	http://www.macalester.edu/research/economics/page/haveman/trade.resources/Data/Gravity/dist.txt
Genetic distance	Genetic distance between two population measures the time elapsed between them since having their common ancestor, where difference in allele frequency proxies for the elapsed time.	Spolaore and Wacziarg (2009)
Growth spillover through geographical proximity (GSPP)	Growth spillover through geographical proximity (GSPP) is defined as, $IV_{it} = [\sum_1^{n-1}(1/d_j) * Growth_{jt}]/\sum_1^{n-1}(1/d_j)$, where d_j is the geographical distance of country j from country *i*.	A detail of construction of *GSPP* is provided in Section 3.
Growth spillover through genetic proximity (GSGP)	Growth spillover through genetic proximity (GSGP) is defined as, $IV_{it} = [\sum_1^{n-1}(1/d_j) * Growth_{jt}]/\sum_1^{n-1}(1/d_j)$, where d_j is the genetic distance of country j from country *i*.	A detail of construction of *GSGP* is provided in Section 3
Private credit	Credit provided to private sector as percentage of GDP	Madsen and Ang (forthcoming)[ab]
Educational attainment	Educational attainment in average years of education.	Madsen (2014)
Average tariff rate (logs)	Nominal import duties divided by nominal import values of goods.	Madsen (2009)
Capital-output ratio (logs)	Logarithm of Capital-output ratio. Capital here refers to the non-residential capital, which is sum of business capital and machinery. Output refers to the real GDP. Both at 2005 constant terms	Madsen (2010)[(a) (b)]

Capital share in GDP	Capital share refers to share of all income other than labor income share in GDP	Madsen (2007)[(a)]
Patent applications domestic (logs)	Number of domestic patent applications	Madsen (2007)
Bank crisis	Share of bank crisis years in 5-year period	Roine *et al.* (2009)
Currency crisis	Share of currency crisis years in 5-year period	Roine *et al.* (2009)

Notes: **(a)** I am thankful to Professor Jakob Madsen of Monash University, who shared his century long private credit data prepared for his ongoing research. In addition, he shared his updated series of capital share in GDP and capital-output ratio data originated from Madsen (2007) and Madsen (2010), respectively. (**b**)The correlation between private credit data of Madsen and Ang (forthcoming) with Global Financial development Database (GFDD) of World bank, and Roine *et al.* data are 0.97 and 0.96, respectively.

Table 3.A2 Summary statistics of the variables

Variable	(1) Obs	(2) Mean	(3) Std. dev.	(4) Min	(5) Max
Per capita GDP growth rate (%)	308	1.99	2.971	-14.77	15.95
Private credit as percentage of GDP	308	65.35	43.16	11.34	214.1
Educational attainment (years)	308	8.86	2.517	0.849	15.20
Average tariff rate (logs)	242	-3.031	1.444	-12.75	-0.734
Govt. expenditure-GDP ratio (logs)	237	-2.139	0.606	-4.506	-1.220
Private saving-GDP ratio (logs)	304	-1.675	0.471	-4.467	-0.667
Patent application domestic (logs)	264	8.689	1.594	4.779	12.83
Capital-output ratio	308	0.621	0.239	0.119	1.971
Capital share in income (%)	242	0.493	0.120	0.049	0.827
Top 1% income share	287	10.92	4.503	3.852	26.71
Top 10% income share	234	35.10	6.528	22.09	60.36
Top 5% income share	286	24.39	5.873	13.10	41.31
Top 0.5% income share	264	8.126	3.779	2.233	20.64
Top 0.1% income share	264	3.915	2.472	0.574	13.65
Top 0.05% income share	110	2.795	2.307	0.318	11.49
GSPP	308	2.301	1.802	-4.739	9.573
GSGP	308	2.113	2.001	-9.092	14.259

Note: Data are average of every 5 years since 1900. Yearly data has been used in constructing GSGP and GSPP. Once the yearly data are porduced, in the final stage, We average them for five years.

Table 3.A3 Correlations among the important variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Top 1%	1						
(2) GDP per capita	0.353	1					
(3) Broad money	0.2883	0.2601	1				
(4) Private credit	0.2312	0.7493	0.4308	1			
(5) Educational attainment	0.3401	0.7644	0.1185	0.4818	1		
(6) Government expenditure	-0.119	0.5046	-0.0307	0.2865	0.1799	1	
(7) Private saving	-0.1546	0.0921	0.3834	0.3203	0.0849	-0.2449	1
(8) Patent	0.3369	0.2531	0.5987	0.4577	0.1855	-0.1627	0.0145
(1) Top 1%	1						
(2) Top 10%	0.8932	1					
(3) Top 5%	0.9572	0.9719	1				
(4) Top 0.5%	0.9903	0.8805	0.9479	1			
(5) Top 0.1%	0.9596	0.8184	0.9004	0.9769	1		
(6) GSPP	-0.3098	-0.2973	-0.3063	-0.3107	-0.323	1	
(7) GSGP	-0.2398	-0.2301	-0.2356	-0.2454	-0.2546	0.8316	1
(8) GDP per capita growth	-0.1437	-0.1427	-0.1484	-0.142	-0.1389	0.3852	0.2702

Genetic distance

Before going to describe genetic distance let us discuss first what are the genes, and the alleles. Genes are the sequences of protein encoded in deoxyribose nucleic acids, which are widely known as DNAs. A gene in a particular locus of a chromosome in a cell is found to have multiple versions, which are known as alleles. New alleles evolve over time through natural selection due to exposure of a group for long in a new environment. Therefore, two siblings, if they are separated for long and live in different bio-geographical exposure, may develop new alleles to adapt with the environment. Thus long departure provides difference in the allelic frequency of two populations separated for long.

Therefore looking into the differences in the allelic frequency we can differentiate two populations in terms of a genetic traits. Genetic distance measures the difference in the allelic frequency between two populations. It is measured as the probability of finding two different versions of the same gene (alleles) at a locus of the chromosome randomly chosen from two populations. It is also expressed as the time elapsed since the two populations had their common ancestors. The connection between the elapsed time and the genetic distance is that the longer the time the two groups are departed from the common ancestors, the larger the difference in the allelic frequency is. Thus measuring the difference in allelic frequencies provides us an impression of how long the two population groups are apart in terms of sharing common genetic traits. Although the traits pass vertically over the generations, the longer elapse time provide more differences in the allelic frequencies between the two groups. Spolaore and Wacziarg (2009) argue that two genetically closer groups share many traits in common that induce them to have easy interaction in terms of trade and other exchanges.

Still we discussed the genetic distance between two populations. In reality, a country comprises of a mixture of many ethnic groups, with different allelic frequencies. Cavalli-Sforza *et al.* (1994) identified 42 main genetic groups across the world with 45 gene-types along with their 128 allele versions. Each genetic group has a very high level of genetic similarity and is differentiable from the others. In the two extremes, the genetic distance is the highest between Papua New Guineans and Mbuti Pygmies with a F_{st} genetic distance of 0.4573, and is the lowest between English and Danish with a F_{st} genetic distance of 0.0021. Spolaore and Wacziarg (2009) compiled genetic distance data of country pairs, where each countries allelic frequency was constructed through weighted average allelic frequency of those ethnic groups. The population fractions of the groups were used as weights in the calculation.

It is important to note that different alleles may or may not provide observable phenotypic traits, such as eye colour or skin colour. If they do not provide observable phenotypic traits, they are called to be selectively neutral alleles. Most of the alleles are selectively neutral, except few.

Genetic distance is measured based on only selectively neutral alleles, which change over long span of time, but without producing any observable phenotypic traits. As a result, starting from the same ancestor, they change proportionally as time passes. Genetic distance is measured by the time elapsed since two groups of people had their common ancestors. The more the time elapsed, the two groups split more apart from one another in terms of their common genetic traits. As genetic distance is a measure of the elapsed time for two genetic groups to have common ancestors, it provides us the opportunity to compare various socio-economic and health outcomes.

There is a strong correlation between genetic proximity (similarity between two genetic groups, measured as the inverse of genetic diversity) and cultural proximity. More specifically, the cultural traits, like the genetic traits, pass on the off-springs over the generations. Therefore, the elapsed time that measures genetic distance can also be a proxy measure of cultural distance between two groups. In fact, genetic and cultural diversity coevolves over the generations, and they coexist at a cross-section of time.

In this work, we use weighted average growth of other countries as an instrument for economic growth of a country. Here genetic proximity is used as a weight to measure the average economic growth of other countries. The idea is simple in that genetic proximity between populations of any two countries can facilitate trade and other exchanges between them. Spolaore and Wacziarg (2013) find that genetically closer countries, due to their similarity both in their genetic and cultural traits, want to exchange more in comparison with their less close counterparts.

Chapter 4: Financial Development and Top Income Shares in the OECD Countries

Abstract: This paper explores the possibility of financial development as a major determinant of top income shares in the OECD countries. In a century long panel of time series data of top income shares and financial development, we attempt to capture the impact of financial development on the income distribution of the top income strata. We use couple of dynamic models to check the robustness of our hypothesis. The results show that a one standard deviation increase in financial development, measured by private credit-GDP ratio, is associated with an increase of the top 1% income shares by around 0.3 standard deviation. The effects are also robust to the other measures of top income shares.

JEL classification: O15; O50; G00; E62

Key words: financial development; top income shares

4.1 Introduction

The concern about the disparity between the top income holders and the rest of the population is not new. Recently the discussion entered into a new phase as century long data of top income shares for many countries have become available beginning with the remarkable work done by Piketty (2001) for France, and is subsequently followed by many others (Atkinson 2004; Saez 2005; Atkinson *et al.* 2011). Figure 4.1 plots the time series of top 1% income shares, defined as top 1% before-tax income (as a percentage of GDP), for fourteen OECD countries. The data reveal that the income gap between the top 1% and the rest has been increasing rapidly in these countries after mid-seventies.

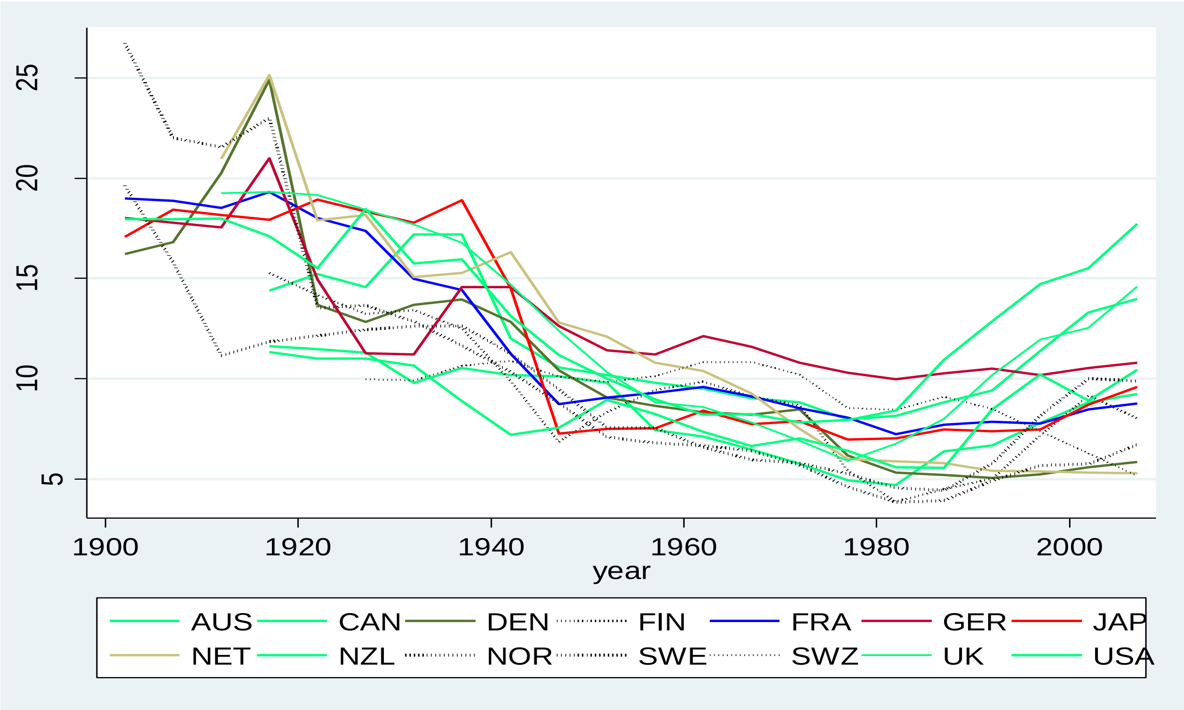
Top income shares are closely related to the financial development. Financial system tends to channel more funds to the rich by requiring collaterals or a history of previous loan repayments. The rich, through their political and social connections, may influence financial development in ways that benefits themselves and retard financial development, at least at the stage before the emergence of massive cross-border trade and capital flows. For example, Rajan and Zingales (2003) argue that incumbent financiers may discourage potential new competitors from entering the financial sector since such a development introduces competitions and reduces their positional rents and profits. These negative effects can offset other benefits that financial development brings.

The existing literature on the relationship between financial development and top income shares is scant. We find only one published paper that analyses an association between financial development and top income shares in a cross country setting. Roine *et al.* (2009) employ an unbalanced panel of 16 countries[22] and identify financial development, among others, to be one of the determinants of top income shares. We aim to contribute to the

[22] They include Argentina and India along with fourteen OECD countries

literature by providing a thorough analysis of the impact of financial development on top income shares.

Figure 4.1 Top 1% income shares over time



Our analysis focuses on fourteen OECD countries over the period 1900-2009.[23] It differs from Roine *et al.* (2009) in the methodology which has the following features. First, we estimate dynamic panel data models to capture the inertia of the top income shares. Top income shares are highly persistent. Until three decades ago, capital income has been a significant component of the top incomes. Even though later labour income constitutes as high as two-third of the top 1% income shares (Atkinson & Leigh 2013), self-employment and labour income of the wealthier people are still very persistent compared to their counterpart-the poor. Moreover, the wealth inherited through bequests enables children of the

[23] Century long top income shares data are not available for all OECD countries. The fourteen countries in our sample include five Anglo-Saxon countries, eight European countries, and Japan.

rich to attain more human capital and to accumulate more assets, maintaining the income gap between the rich and the rest of the population.

Secondly, we adopt various estimation techniques that are suitable for our objective as well as data features. The primary concern of Roine *et al.* (2009) is to find various determinants of top income shares, and therefore they address the endogeneity between financial development and top income shares to the limited extent by controlling only for the trends and time invariant country specific factors through first differencing. [24] Our paper aims to investigate the impact of financial development on top income shares, thus cannot avoid the issue of financial development being endogenous. Furthermore, for our unbalanced panel, the number of countries N and the number of time periods T are both moderate (N=14, T=22).[25] Estimators that are able to mitigate the endogeneity problem may be less efficient in panels with moderate N and T. On the other hand, estimators that are suitable for such panels may be unable to tackle the endogeneity issue. Thus we use a range of estimators including the difference and system general method of momentum (hereafter GMM), corrected least square dummy variables (corrected LSDV), and various mean group estimators (MG) and compare the results to see how they differ across the estimations.

Third, we also accommodate cross-sectional dependence in the estimation. The analysis in Roine *et al.* (2009) covers Argentina and India, along with fourteen OECD countries while we are exclusively interested in the fourteen OECD countries. [26] OECD countries share many common features in economic development and have wide spatial relationship among themselves through capital flows and trade of goods. Shocks generated in one country can easily spill over to others although the impacts of shocks may differ across

[24] They used first differenced generalized least square (FDGLS) and dynamic first differences (DFD) methods.
[25] We take the five year average over the period 1900-2009, resulting in 22 time periods.
[26] The fourteen countries in our sample are not exactly the same as in Roine *et al.* (2009). We delete Ireland and Spain as they have very few observations of top income shares. We add Norway and Denmark in our analysis as the data recently become available.

countries. Our test confirms the existence of a high degree of interdependence among these countries. Ignoring such a cross sectional dependence would render our coefficient estimation biased and inconsistent. We therefore take this into account using the Common Correlated Error Mean Group (CCEMG) estimator proposed by Pesaran and Chudik (2014).

Using different estimation methods, we consistently find that financial development has a positive and significant impact on various top income groups, including 0.1%, 0.5%, 1%, and 5% top income shares. This contrasts to the result obtained in Roine *et al.* (2009), where they find that financial development has a positive impact only on top 1% income shares, and there is no significant impact on the lowest 9% of the top 10% income shares.

The rest of the paper proceeds as follows. Section 2 discusses the existing theoretical and empirical studies on the relationship between financial development and top income shares. Section 3 describes empirical methodologies, followed by descriptions of variables and data sources in Section 4. Section 5 discusses the results. The final section concludes.

4.2 Financial development and income inequality

Financial development can directly affect income distribution to the extent people, irrespective of their income and wealth status, can access financial services. Indirectly, financial development affects income inequality through a number of channels.

One important channel proposed by existing studies is the imperfection of the capital market. In Galor and Zeira (1993), capital markets are imperfect as the interest rate for borrowers is higher than that for lenders due to enforcement costs. Education is then limited to individuals with high enough initial wealth. The offspring of the rich who receive a bequest from their parents have better access to investment in human capital, and become skilled labor and earn higher income, while people from poor dynasties inherit less and work as unskilled and earn less income. As a result, income inequality is perpetuated over generations. Banerjee and Newman (1993) assume a similar imperfect capital market where amount of borrowing is limited. Thus occupations that require more investment are beyond the reach of poor people, who choose to work for wealthier employers. Therefore the initial wealth distribution determines occupational choices, which in turn form a new distribution of wealth. Both papers predict that as capital markets become less frictional along with financial development, the income gap in the society will be reduced.

Another is the growth channel. Financial development helps allocate capital efficiently and promote economic growth (King & Levine 1993; Beck *et al.* 2000). But the impact of growth on income distribution is inconclusive in the literature. Chambers (2007) and (Lopez 2006), for instance, find growth to increase inequality. On the other hand, (Dollar *et al.* 2013) find the opposite. The inverted U-shaped Kuznets curve (Kuznets 1955) shows an initial rising of inequality in the early stages of development and a diminishing inequality as the economy reaches to a matured stage in the long run.

One influential paper is Greenwood and Jovanovic (1990), where both financial development and growth are endogenous and jointly determined. Financial intermediaries arise endogenously to facilitate trade in the economy by overcoming information frictions and pooling risks across many investors. Thus development of financial institutions, by enabling individual investors to obtain a higher and safer return, feeds back on economic growth and income levels. Economic growth will also foster financial development as investment in organizational capital is costly. They show that only agents with a capital stock endowment exceeding some threshold level will invest through financial intermediaries (participate in the exchange network, in their language) and earn a higher return. Thus the dynamics of financial development, growth, and income distribution resemble the Kuznets (1955) hypothesis. As the economy's growth increases, financial structure begins to form and the income gap between the rich and the poor widens. In the later stage of development, the growth rate converges to a higher level, financial intermediation is extensively developed, and the income distribution stabilizes.

Clarke *et al.* (2006) empirically test Greenwood and Jovanovic (1990) hypothesis using data of 83 countries between 1965 and 1995. Measuring income inequality by Gini coefficient, they found an inverted U-shaped relationship of financial development and income inequality – a rising trend of inequality in the earlier stages of financial development, and a falling one in the matured stages, supporting the Greenwood-Jovanovic model. Their results are more robust for the long run in comparison with the short run. Claessens and Perotti (2007) also maintain the same argument that financial development cannot as much benefit the poor in the short run as it benefits the rich due to poor's lack of collateral and credit history. Similar argument comes from Kim and Lin (2011), who contend that a threshold level of financial development is a precondition to successfully improve the income distribution in a society. In fact, financial development has an inequality-narrowing impact in the society, at least in the long run. Using data of 72 developed and developing countries, Beck *et al.* (2007) identify that financial development improves the income of the poor through the channel of increasing income growth and reducing inequality growth.

Most of the empirical studies we have discussed so far use Gini coefficient as a measure of inequality. The use of top income shares as a measure of inequality in the literature is limited and recent (Roine *et al.* 2009; Andrews *et al.* 2011). Recently Piketty (2014) argues that the positive gap between return to capital and the economic growth would widen the income gap between the top and the rest. If return to capital is greater than the average economic development, capital will be accumulating in the hands of the rich, and eventually it will fatten up their wealth. The poor, on the other hand, mainly live on their labor income, and will gradually lose their bargaining power against the rich, who are capital owners. In the context of our analysis, if financial development is pro-rich, it will augment capital to generate further higher return in comparison with the economic growth, and hence will reinforce Piketty's capital accumulation argument.

4.3 Empirical models

We first discuss estimation models assuming that the intercepts and slopes are homogenous in different countries. Next we adopt estimation methods that allow for heterogeneity in the coefficients across countries. Finally, we introduce the Common Correlated Error Mean Group estimator to capture the cross-sectional dependence.

4.3.1 Models with homogenous intercepts and slopes across countries

We start with the estimation of the following unobserved effect model to investigate how top income shares are related to financial development.

$$TOP_{it} = \alpha TOP_{it-1} + \beta FD_{it} + \gamma' * CV_{it} + h_i + u_{it}, \quad (1)$$

where i refers to countries, t to time, h_i represents country-specific fixed effects, CV is a vector of exogenous control variables, and u_{it} is the error term. The dependent variable TOP_{it} is the top income shares, and FD_{it} represents financial development. The lagged dependent variable TOP_{it-1} is included to capture the dynamicity of the top income shares, which are known to be highly persistent. The coefficients are denoted by α, β, and γ, of which β is the coefficient of main interest. Apart from possible omitted variable bias and measurement errors, ordinary least square (OLS) estimates, although efficient, could suffer from severe endogeneity problem. For instance, the relationship between financial development and top income shares may suffer from causality running in both the directions.

Thus FD_{it} may be correlated with the error term. Besides, both FD_{it} and TOP_{it-1} in equation (1) could be correlated with the country specific fixed effects, h_i.

To address the endogeneity, one way is to use instruments to exploit the exogenous components of the explanatory variables. But finding out instruments for financial development is extremely difficult, especially in a panel setting. The earlier literature used creditors' right and legal origins as instruments for financial development, but they are only mainly suitable for cross-section analysis (La Porta *et al.* 1997; Beck *et al.* 2000). Moreover, century long creditors' right, or protection to creditors, data are simply not available. Thus to deal with the endogeneity issue, we difference equation (1) and estimate the differenced model, represented by equation (2), using lags of the explanatory variables as instruments, either in level or in differences (Anderson and Hsiao (1981), AH thereafter):

$$\Delta TOP_{it} \quad = \quad \alpha \Delta TOP_{it-1} + \ \beta \ \Delta FD_{it} + \Delta CV_{it}' * \gamma + \Delta u_{it} \qquad (2)$$

The AH technique, again, could be vulnerable to misspecification problem if the true model has a different dynamics than the specification we described, or if the instruments are weak. The misspecification can arise through wrong choice of lags of any of the variables in the right hand side of the equation. On the other hand, AH estimation cannot use all the available instruments because each additional lag of the dependent variable reduces the number of observations in the regression by the number of countries (N). Furthermore, the instruments may become weak to the extent the dependent variable is persistent.

To further mitigate the instrument problem, we use the Arellano and Bond (1991) two-step difference GMM estimator (AB thereafter) and the Blundell and Bond (1998) two-step system GMM estimator (BB thereafter) to estimate a linear dynamic panel-data model. The difference GMM uses all the available instruments in each period to improve the asymptotic efficiency without losing available observations. However, in the presence of highly persistent dependent variable, as in our case, difference GMM estimator may not be a good choice because persistent variables in levels cannot work as good instruments for the first difference of those (persistent) variables. The system GMM approach performs better than both the AH and AB estimators. It combines equation (1) and (2), and uses lagged differences of the regressors as instruments in the level equation, and level values of the regressors as instruments in the differenced equation. The difference and system GMM provide consistent estimates, mitigate the potential endogeneity of the explanatory variables, and are asymptotically efficient and robust to arbitrary heteroskedasticity. However, the efficiency of these estimations relies on the number of countries N being large and number of time period T being small.

If T is large, and N is small or moderate, as in the case of typical macro panel data including ours, corrected least square dummy variables approach (corrected LSDV) can produce efficient estimates (Bruno (2005). However, this technique also has limitations – it is suitable for strictly exogenous explanatory variables.

All the techniques discussed above assume intercept and slope homogeneity across countries. Next we relax this implausible assumption and discuss estimation methods that allow for heterogeneity along these dimensions.

4.3.2 Models with heterogeneous intercepts and slopes across countries

We adopt the mean group (MG) estimations of panel time series that are widely used recently to allow the intercepts, the slope coefficients, and error variances to be heterogeneous across countries (Pesaran and Smith (1995); Pesaran (2006)). We also consider long run cointegration among the variables, where the short run dynamics could be different from the long run. Among the mean group estimators, we consider simple MG estimator that uses simple average of the coefficients and intercepts across the groups, the dynamic fixed effect (DFE) estimator that allows intercepts to differ across countries while keeping slope coefficients the same, and the pooled mean group estimator (PMG) that allows the intercept, the short run coefficients, and the error variances to differ across countries, but restricts the long-run coefficient to be equal across countries, and is estimated through maximum likelihood method, allowing non-linearity in the parameters.[27]

Equation (1) can be rewritten for the MG and PMG estimators in the following form:

$$\Delta TOP_{it} = \emptyset_i\left(TOP_{i,t-1} - \theta'_i X_{it}\right) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta TOP_{it-1} + \sum_{j=0}^{q-1} \delta_{ij}^* \Delta FD_{i,t-j} + h_i + \epsilon_{it}, \quad (3)$$

where $X = [FD \quad CV]'$, $\emptyset_i$ is the speed of adjustment term for error correction, θ_i refers to the vector of coefficients of the matrix *X* that include our main explanatory variable, and λ_{ij}^* and δ_{ij}^* are the coefficients for the lagged first differenced explanatory variables. Note that for PMG estimators, the long run coefficient θ'_i will be independent of country *i*. i.e., $\theta'_i = \theta'$.

The above mean group estimators require the number of groups (*N*) and the number of time periods (*T*) to be large enough to achieve asymptotic efficiency. Our unbalanced panel consists of moderate number of both *N* and *T* (*N*=14, *T*=22).[28] The next subsection deals with this problem.

4.3.3 Models incorporating cross-sectional dependence

To estimate panels with moderate *T* and moderate *N*, we adopt two other types of MG estimators: (1) augmented mean group (AMG) estimator of Eberhardt (2012), Eberhardt and Teal (2011), and Eberhardt and Bond (2009), and (2) the Common Correlated Error Mean

[27] The pooled mean group estimators possess part of the characteristics of fixed effect estimators.
[28] See stata help menu of “xtmg” command for details that describes N=15 and T=15 as “moderate-T, moderate-N” in a macro panel.

Group (CCEMG) estimator of Pesaran (2006). One nice feature of these estimators is that they not only allow for the slope and intercept heterogeneity across countries, but also allow for the cross-sectional dependence. Incorporating cross-sectional dependence is ideal for our analysis as the fourteen OECD countries have wider spatial relationship among themselves through capital flows and trade of goods so that shocks in one country can easily be transmitted to the others. These common shocks can only be captured in models that account for cross sectional dependence. The following equation accommodates cross-sectional dependence among the countries:

$$u_{it} \quad = \rho_i * f_t \; + \; \varepsilon_{it}, \qquad (4)$$

where u_{it} is the error term in equation (1), f_t is the common shock at time t, and ρ_i is the factor loading for country i which allows common shocks to have different impacts in different countries. The AMG and CCEMG estimations thus combine equation (1) and (4).

The AMG estimator by Eberhardt and Teal (2011) uses pooled regression model. Firstly, the model is augmented with year dummies to estimate first-differenced OLS estimates. The coefficients of the differenced year dummies are then collected as a representative of the estimated cross-group average of the evolution of unobservable common factors over time. Group-specific coefficients are then estimated by augmenting the cross group average of unobservable common factor in the model, which captures time-variant fixed effects. The captured effect is also known as common dynamic process.

According to Phillips and Sul (2003), introducing cross sectional dependence into a dynamic panel like ours, renders the estimation less efficient. For example, the introduction of lagged dependent variables in the CCEMG estimator complicates the desired coefficient measurement due to the fact that the coefficient heterogeneity in the lags of the dependent variable introduces lag polynomials of infinite order in the relationships between cross-sectional averages as well as the unobserved factors (Chudik & Pesaran 2012; Pesaran & Chudik 2014). By conducting Monte Carlo experiments, Chudik and Pesaran (2013) show that introducing sufficient number of lags of cross-section averages in the individual equations of the panel can regain the efficiency of the CCEMG estimator, provided that the number of cross-section averages is at least as large as the number of the unobserved common factors.[29]

The CCEMG estimator is mostly preferred by us because it not only accommodates cross-sectional dependence across countries and characterizes the dynamics of the dependent variable, but also has fewer limitations comparing with other techniques discussed so far. For comparison purpose, we also use all the other approaches discussed above.

4.4 Data and Variables

Our analysis utilizes panel data of fourteen OECD countries over the period 1900-2009. Below we describe the dependent variable and explanatory variables. All the variables are converted to natural logarithm for ease of interpretation. We average the data over five years to smooth out short-run business cycle fluctuations. Since not all variables have observations in every year, taking five-year averages also mitigates the missing data problem. Although the variability of the data is compromised to some extent, the non-overlapping five-year-period average over the full sample period provides us with the ground for long run inference. Variable descriptions and data sources are presented in Table 4.A1 in the Appendix. Table 4.A2 provides summary statistics of the key variables.

[29] Stock and Watson (2002), and Giannone *et al.* (2005) argue that a few, such as only two, unobserved common factors could explain much of the predictable variations.

4.4.1 Measures of top income shares and financial development

Top income shares are measured by before-tax income as a percentage of GDP. We use top 1% income share in benchmark regressions and top 0.1%, 0.5%, 5%, and 10% income shares for the robustness check. The data are from the World Top Income Database of Paris School of Economics. They provide comparable series of top income shares across the countries, although potential problems regarding different income definitions, income tax units, and change in legislation at different points of time across the countries cannot be avoided completely (see Atkinson (2005) for details). However, we mitigate this problem by focusing on fourteen OECD countries, all of which are high income countries engaging in large trade with each other. The rich across the OECD countries are similar in many respects: from the way they manage their portfolios, to the way they maintain their ties with politicians and bureaucrats.

Financial development is measured by private credit (credit to private sector as a percentage of GDP), which is a standard measure in the literature (Beck *et al.* 2007). We employ the century long private credit data from Madsen and Ang (forthcoming). Global Financial Development Database (GFDD) of the World Bank also provides data on private credit, but the data start only from 1960.[30]

4.4.2 Other variables

We control for the level of GDP per capita in all the regressions, as economic development is known to be highly correlated with both financial development and top income distribution. Financial development in general promotes economic development, and vice versa, and economic development on the other hand might have a strong influence on

[30]The correlation of Madsen and Ang's private credit data with GFDD data is 0.97.

top income shares.[31] The data for real GDP per capita (in 1990 International Geary-Khamis dollars) come from Maddison Project Database. [32]

Changes in tax policies can have a significant impact on top income shares. The top marginal tax rate is an effective policy tool to downsize the top income shares. For example, by implementing higher statutory marginal tax rates, Denmark reduced its top 1% income shares from its maximum of 28% in 1917 to about 6% in 2010 (Atkinson & Søgaard 2013).[33] Atkinson and Leigh (2013) find a rise in the top income shares due to a drop in the top marginal tax rates on wage income, as well as on investment income. Progressive taxation is one of the tools advocated in Piketty (2014) to minimize the income gap between the rich and the poor. Thus we also control for top marginal tax rates. These tax rates are statutory top tax rates, except for the UK and the USA, where the top marginal tax rates are tax rates that incomes greater than five times of the GDP per capita are subject to. The data are taken from Roine *et al.* (2009), except for Denmark. The Denmark data come from Atkinson and Søgaard (2013). Note that top marginal tax rate data are unavailable for Netherlands, Norway, and Switzerland.

Existing studies also point out the importance of trade openness in the relationship between financial development and income distribution (Rajan and Zingales (2003). It is argued that the rich would welcome financial development to the extent a country is open to the international goods and capital market. We use trade openness data from Roine *et al.* (2009) that measure total import and export as a percentage of GDP.

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[31]Andrews *et al.* (2011), for example, using data of 12 OECD countries, found a positive effect of top income shares on economic growth in 1950s onward. However, they did not find any systematic impact of the top income shares on economic growth in the whole twentieth century.

[32] Madison Database provides data on population, GDP and GDP per capita for all countries in the world for the period 0-2010. See http://www.ggdc.net/maddison/maddison-project/home.htm for details.

[33] However, the trend is not secular.

Finally we note that technological development may also have substantial impact on top income shares. Adoption of new technologies predominantly increases the demand of high-skill workers that exacerbate the wage gap through providing skill-based high remuneration (Jerzmanowski and Nabar (2013). Technological development, specifically information and communication technology, has been continuously reshaping the financial sector, and also, changing the distribution of income in the society. We use research and development expenditure (R&D) as a percentage of GDP from Madsen and Ang (forthcoming) to measure the technological development of a country.

Ideally we would like to also include variables that are able to capture the political inequality in the society as well as social connections of the rich. However, there are no established such measures, making it difficult to quantify the extent to which the rich reap the benefits of financial development through political and social connections. Using lagged top income shares as explanatory variables may capture some of these effects as such connections do not remarkably change over time. On the other hand, the cross-sectional dependence incorporated in our estimations also help capture some of the influences.

4.5 Results and discussions

4.5.1 Basic results

Table 4.1 presents the OLS, LSDVC, and GMM estimation results, controlling for GDP per capita (Panel A) and GDP per capita as well as top marginal tax rates (Panel B).

The ordinary least square (OLS) regression results are reported in Column (1a), (1b), and (1c). In column (1a), we regress top 1% income shares on private credit only. The impact of private credit seems to be insignificant on top 1% income shares. In column (1b), we include the first lag of the top 1% income shares as an explanatory variable. The coefficient of financial development becomes significant at 1% level, and the R^2 value increases substantially (from 0.004 to 0.884). A one percent increase in financial development, measured by private credit as percentage of GDP, is associated with an increase of 0.05 percent in the top 1% income shares. In column (1c), we include GDP per capita along with the lagged top 1% income shares. The coefficient of private credit remains significant at 1% level while GDP per capita does not show any significant impact on top 1% income shares.

Table 4.1 OLS, LSDVC, and GMM estimates

DV: TOP1%	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)
	OLS estimates			Corrected LSDV estimates			GMM estimates	
	No control	Add lagged DV	Add GDP per capita	initiated by AH estimator	initiated by AB estimator	initiated by BB estimator	System GMM	Difference GMM
Panel A: Without controlling for top marginal tax rates								
Private credit	-0.04	0.05***	0.04***	0.12***	0.10***	0.08***	0.14***	0.17***
	[-0.07]	[0.08]***	[0.07]***	[0.22]***	[0.17]***	[0.15]***	[0.25]***	[0.30]***
	(0.031)	(0.011)	(0.012)	(0.036)	(0.021)	(0.019)	(0.020)	(0.023)
GDP per capita			0.004	-0.088*	-0.021	0.006	-0.043	-0.112**
			(0.022)	(0.052)	(0.024)	(0.016)	(0.034)	(0.052)
Lagged DV		0.92***	0.92***	0.83***	0.95***	1.04***	0.91***	0.84***
		(0.026)	(0.036)	(0.088)	(0.044)	(0.027)	(0.055)	(0.087)
Constant	2.5***	-0.031	-0.047				0.001	0.692
	(0.122)	(0.082)	(0.253)				(0.393)	(0.646)
Observations	288	274	262	262	262	262	262	248
R-squared	0.004	0.884	0.884					
Countries	14	14	14	14	14	14	14	14
Panel B: Controlling for top marginal tax rates								
Private credit		0.04***	0.02*	0.12**	0.08***	0.08***	0.11***	0.15***
		[0.07]***	[0.04]*	[0.20]**	[0.15]***	[0.14]***	[0.20]***	[0.26]***
		(0.010)	(0.013)	(0.048)	(0.028)	(0.028)	(0.023)	(0.040)
GDP per capita			0.033	-0.085	-0.02	0.005	0.002	-0.016
			(0.027)	(0.068)	(0.040)	(0.039)	(0.029)	(0.062)
Top marginal tax rate		-0.07***	-0.08***	-0.07	-0.07**	-0.05	-0.10***	-0.12***
		(0.024)	(0.025)	(0.061)	(0.032)	(0.038)	(0.038)	(0.034)
Lagged DV		0.88***	0.91***	0.773***	0.877***	0.972***	0.916***	0.926***
		(0.032)	(0.038)	(0.102)	(0.074)	(0.086)	(0.050)	(0.079)
Observations		187	182	182	182	182	182	170
R-squared		0.896	0.896					
Countries		11	11	11	11	11	11	11

Note: All the variables are in logarithms. Column (2a), (2b) and (2c) report the corrected least square dummy variable (LSDVC) estimates, initiated by AH, AB, and BB estimators, respectively. The beta coefficients are in square brackets. Beta coefficients are obtained by transforming all the variables in the distribution with zero mean and unit standard deviation.

Compared with Column (1a), results in Column (1b) and (1c) imply that a dynamic panel-data model is more suitable to characterize the relationship between financial development and top income shares. Regression in Column (1c), although explains 88% of the variations of the dependent variable, still doesn't address the reverse causal effect of top income shares on financial development.

Column (2a), (2b) and (2c) report the estimation using corrected least square dummy variable (LSDVC) techniques, initiated by AH, AB, and BB estimators, respectively. LSDVC technique is claimed to be efficient in a narrow unbalanced panel with long time series, as in our case. The estimated coefficient of financial development increases substantially in comparison with the OLS estimates and is significant at 1% level. However, as discussed before, the LSDVC estimator requires the explanatory variables to be strictly exogenous.

System and difference GMM techniques have an advantage of addressing feedback effect of the dependent variable on the explanatory variables. We present the estimation results in Column (3a) and (3b). One can see that the coefficient of private credit is positive and significant at 1% level. And the magnitude of this coefficient is much larger compared with the OLS and LSDVC estimates. A one percentage increase in private credit leads to an increase in top 1% income shares that is two or three times larger than the increase estimated by OLS.

Above discussions are based on Panel A where we only control for GDP per capita. We find that financial development has a significant positive impact on top 1% income shares. In panel B, top marginal tax rate is included as an additional control variable. Results show that our coefficient of interest remains positive and significant, and is slightly lower than the coefficient obtained in Panel A. The impact of top marginal tax rate on top income shares is always negative, as is expected; however, in presence of financial development variable, the impact of tax policy is not always significant. Note that we lose some observations due to the non-availability of marginal tax rates data of Netherlands, Norway and Switzerland.

Table 4.2 reports the results of the mean group estimations (MG), pooled mean group estimation (PMG), and dynamic fixed effect estimation (DFE) through error correction in the long run. All the variables included in the regressions are tested to be $I(1)$. The results confirm a long run relationship between private credit and top 1% income shares. The adjustment terms ($\emptyset_i$) that characterize the error-correction speed are significant at 1% level across the estimators with an expected negative sign. Across the estimates, private credit has positive impact, and GDP per capita has negative impact on top 1% income shares. However, the impacts are highly significant only in the PMG and DFE estimates. The Hausman test between the groups suggests DFE to be the most efficient estimator among the three estimators. The results do not show any significant short run impact.

Table 4.2 Estimation through error correction models

	Mean group (MG)		Pooled Mean Group (PMG)		Dynamic Fixed Effect (DFE)	
	(1a) LR	(1b) SR	(2a) LR	(2b) SR	(3a) LR	(3b) SR
	Dep. Var.: Top 1% income shares					
Private credit	0.262		1.240***		0.749***	
	(0.638)		(0.258)		(0.179)	
GDP per capita	-2.145		-0.484***		-0.511***	
	(1.681)		(0.074)		(0.086)	
Error correction ($\emptyset_i$)		-0.281***		-0.132***		-0.182***
		(0.101)		(0.036)		(0.045)
ΔPrivate credit		-0.018		-0.025		-0.025
		(0.061)		(0.063)		(0.046)
ΔGDP per capita		0.084		0.072		0.103
		(0.118)		(0.123)		(0.119)
Constant		1.560**		0.178***		0.680**
		(0.714)		(0.051)		(0.303)
Observations	262	262	262	262	248	248

Note: All the variables are in logarithms. Im-Pesaran-Shin panel unit-root tests indicate that all the main variables-private credit, top 1% income shares, and GDP per capita are I(1). Non-zero, negative $\emptyset_i$ confirms a long run relationship between private credit and top 1% income shares at 1% level of significance. Comparison among the estimators through Hausman test detects that DFE estimates are preferable.

Results incorporating the cross-sectional dependence are summarized in Table 4.3. We first estimate the fixed effect (FE) and the random effect (RE) models and conduct the cross-sectional dependence tests using techniques developed in Pesaran (2006), Friedman (1937) and Frees (1995). The first two columns of Table 4.3 show the existence of a highly significant interdependency across countries in our panel, rendering the FE and RE coefficients biased and inconsistent.

In column (3) and (4), we report the estimation of our model augmented with cross-sectional dependence term shown in equation (4) using augmented mean group (AMG) estimator and the Common Correlated Error Mean Group (CCEMG) estimator. Like the other mean group estimators reported in Table 2, each regression here allows for coefficient heterogeneity. One can see that the AMG estimator also provides significant coefficient estimate of our model for the impact of private credit on top 1% income shares. Moreover, the common dynamic process captured by the coefficient of differenced year dummies is also significant at 1% level. In the CCEMG estimation with no lagged dependent variable (Column 4), the effect of private credit on top 1% income shares is positive and significant at 5% level. Moreover, the coefficient of the common factor, estimated as the cross-group average of the dependent variable, is significant at 1% level. The high significance of the common unobserved factor reinforces the existence of cross-sectional dependence of the countries.

Column (5)–(7) in Table 4.3 summarize the CCEMG estimation results when various lagged variables are included in the right hand side of the regression equation. In Column (5), the first lag of the dependent variable is introduced as an explanatory variable to capture the high persistence of the dependent variable. The estimated coefficient of private credit is positive (0.16) and significant at 1% level. In Column (6), we include the first lag of the explanatory variables (private credit and GDP per capita) as additional regressor. In column (7), second lag of the dependent variable is further included. Note that the coefficient of the private credit has similar magnitude (0.17 and 0.21, respectively), but at a lower significance level (10%). Nevertheless, throughout the three columns, the averages of the dependent variable across the units are quite large and all significant at 1% level, further indicating a high degree of interdependency among the countries that we analyse.

Table 4.3 FE, RE and MG estimations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimators	*FE*	*RE*	*AMG (no lagged dep. Var.)*	*CCEMG (no lagged dep. Var.)*	*CCEMG (with 1st lag of dep. Var.)*	*CCEMG (with 1st lag of dep. Var.+ ind. var.)*	*CCEMG ((6) plus 2nd lag of dep. var.)*
				Dep. Var.: Top 1% income shares			
Private credit	0.28***	0.26***	0.12***	0.20**	**0.16*** **	0.17*	0.21*
	[0.49]***	[0.44]***	[0.21]***	[0.35]**	**[0.28]*** **	[0.31]*	[0.38]*
	(0.031)	(0.030)	(0.038)	(0.086)	**(0.051)**	(0.107)	(0.111)
GDPPC	-0.554***	-0.537***	0.081	0.078	0.022	0.19	0.017
	(0.024)	(0.023)	(0.114)	(0.134)	(0.162)	(0.209)	(0.233)
Country trend			-0.011	-0.01	-0.011	0.011	-0.009
			(0.018)	(0.026)	(0.023)	(0.043)	(0.064)
Avg. of Dep. Var.				0.735***	0.799***	0.820***	0.750***
(across the units)				(0.063)	(0.125)	(0.285)	(0.264)
Lag1 of dep. Var.					0.365***	0.099	-0.027
					(0.097)	(0.086)	(0.196)
Lag2 of dep. Var.							-0.215
							(0.137)
Common dynamic process			1.019***				
(Differenced yr. dummies)			(0.171)				
Intercept	6.171***	6.121***	1.876**	-0.375	-0.277	0.053	-0.992
	(0.174)	(0.181)	(0.938)	(1.773)	(1.170)	(3.748)	(4.609)
Observations	276	276	276	276	262	262	248
R-squared	0.69						
Number of countries	14	14	14	14	14	14	14
X-sectional Dependence exists?	Yes	Yes					
RMSE			0.092	0.079	0.061	0.035	0.024

Note: All the variables are in logarithms. In column (1) and (2), Pesaran, Friedman, and Frees cross-sectional dependence tests have been performed for the FE and the RE models. All of the tests confirm the existence of cross-sectional dependence among the groups at 1% level. In comparison with RE, Hausman test shows that FE estimates are preferable. In column (3) to (7), all coefficients represent averages across countries. Coefficient averages computed as outlier-robust means. The cross-section averages of variables with lags are not reported for brevity. Country trend refers to group-specific linear trend. The beta coefficients are in the square brackets.

One noticeable point in Table 4.3 is that GDP per capita has no significant impact on top income shares across the mean group estimators. This result greatly contrasts with the highly significant coefficients of GDP per capita in PMG and DFE estimations (Table 2). It seems that the cross-sectional dependence absorbs much of the effect of GDP per capita. Once the cross-sectional dependence is allowed, income level does not exert any direct impact on top income shares.

Thus far we have established our main result: in the fourteen OCED countries that we analyse, financial development measured by private-credit/GDP has a positive and significant effect on top 1% income shares. When we allow for coefficient heterogeneity and cross-sectional dependence (Column 5, for example), a one standard deviation improvement in private credit (*sd*=0.722, see Table 4.A2) will increase the top 1% income shares by about 12 percentage points, which is about 30% of its own standard deviation (*sd*=0.407, see Table 4.A2). The CCEMG estimation in Column (5) is the benchmark model which will be focused on in the robustness regressions below.

4.5.2 Other measures of top income shares and additional control variables

In this subsection we conduct robustness check to see whether our main result of financial development is still positively affecting top income shares in OECD countries subject to different measures of top income shares, or additional control variables.

Table 4.4 Robustness check using various measures of top income shares

	(1)	(2)	(3)	(4)
Dep. Var. →	Top 10%	Top 5%	Top 0.5%	Top 0.1%
Private credit	0.072	0.177***	0.163**	0.221**
	[0.297]	[0.547]***	[0.263]**	[0.258]**
	(0.048)	(0.021)	(0.078)	(0.102)
GDPPC	-0.009	-0.108	0.142	0.008
	(0.092)	(0.128)	(0.134)	(0.132)
Country trend	0.002	0.003	-0.019	-0.024
	(0.018)	(0.017)	(0.024)	(0.030)
Avg. of Dep. Var.	0.821**	0.854***	0.863***	0.918***
(across the units)	(0.324)	(0.243)	(0.175)	(0.144)
Lag of dep. var.	0.503***	0.470***	0.380***	0.395***
	(0.103)	(0.095)	(0.091)	(0.037)
Observations	195	242	204	224
Number of countries	11	13	11	12
RMSE	0.026	0.041	0.061	0.069

Note: All the variables are in logarithms. All coefficients represent averages across countries. Coefficient averages computed as outlier-robust means. The cross-section averages of variables with lags are not reported for brevity. Country trend refers to group-specific linear trend. The beta coefficients for private credit are in the square brackets.

Table 4.4 reports the regression results of the benchmark specification using various measures of top income shares under the benchmark specification in column (5) of Table 3. The results show that private credit positively impacts the top 5% income holders and their richer companions. A one percent increase in private credit is associated with an increase of 0.18, 0.16, and 0.22 percent in the top 5%, 0.5%, and 0.1% income shares, respectively. The effect on top 10% income shares is small and insignificant.

Table 4.5 Robustness check with additional control variables

DV: TOP1%	(1) *(Add top marginal tax rates)*	(2) *(Add R&D Intensity)*	(3) *(Add Trade openness)*
Private credit	0.218*** [0.404]*** (0.077)	0.202*** [0.359]*** (0.077)	0.235** [0.408]** (0.095)
GDPPC	0.108 (0.177)	0.102 (0.166)	0.172 (0.234)
Top marginal tax rates	0.059 (0.121)		
R&D Intensity		-0.034 (0.115)	
Trade openness			-0.119 (0.130)
Country trend	-0.007 (0.025)	0.001 (0.027)	0.009 (0.040)
Avg. of Dep. Var.	1.023*** (0.090)	0.739*** (0.103)	0.954*** (0.184)
Lag of dep. var.	0.335* (0.188)	0.287*** (0.094)	0.306*** (0.109)
Observations	177	262	224
Countries	10	14	14
RMSE	0.055	0.049	0.033

Note: All the variables are in logarithms. The constant and the cross-section averaged regressors are not reported for brevity. Country trend refers to group-specific linear trend. The beta coefficients are in the brackets.

Table 4.5 reports estimation results for the benchmark model with additional control variables. We include as explanatory variable, one at a time, top marginal tax rates, R&D intensity, and trade openness.[34] The dependent variable is still the top 1% income shares. Overall, the impact of financial development on top income shares remains largely the same irrespective of the inclusion of additional control variables. The coefficients of private credit

[34] Note that the number of countries in Column (1) is 10. In addition to the three countries whose data on top marginal tax rates are unavailable, Finland is automatically dropped due to few observations.

are significant at 1% level, and more than 40% higher than the coefficient in the benchmark case (Column 5, Table 3). Interestingly, none of the additional control variables have any significant impact on top income shares. Technology and trade openness seem to have no direct impact on top income shares, but through financial development. Progressive taxation, as a policy measure, also, seems to have no significant effect on top income shares.

4.6 Conclusions

Until today, there exists very little empirical research on the impact of financial development on top income shares. This is the ever first work that exclusively investigates this relationship in an OECD countries' setting. The results report that financial development in general increases the top income shares. Once the persistence of top income shares and the cross-sectional dependence among the countries are accounted for, financial development remains the only determinant that significantly affects top income shares. As a by-product of this work, in the long run, we do not find any significant impact of top marginal tax rates on top income shares.

Over the century, top marginal tax rates are used as tools aiming to downsize the top income shares. Piketty (2014) advocates in favour of progressive taxation as well as global wealth taxation as tools to minimize the income gap between the rich and the poor.[35] Our study however did not find any significant impact of progressive taxation on top income shares in the OECD countries. It could be due to the fact that the sample size is quite small (only 10 OECD countries). If it is true, it will reduce the hope put forward by Piketty (2014) to use global progressive taxation as a tool in narrowing down income gaps in societies. In that context, we need to rethink and revise the existing financial development policies to

[35] For Anglo-Saxon countries, Atkinson and Leigh (2013) also find progressive taxation on both investment and wage income to reduce top income shares.

ensure pro-poor outcome, not only in the long run but in the short run as well. A natural next step of this study could be a thorough examination of the impact of progressive taxation on the top income shares.

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Appendix

Table 4.A1 Description of variables

Variable	Description	Source
Top income shares	Data are downloaded from World Top Income Database of Paris School of Economics. They are before tax data and are in % of GDP. The data are derived from the tax returns of the countries.	*World Top Income Database* (*Paris School of Economics)*
Private credit	Credit to private sector as percentage of GDP	Madsen and Ang (forthcoming)*
GDP per capita	Per capita real GDP in 1990 International Geary-Khamis dollars, from Maddison Project Database.	http://www.ggdc.net
Trade openness	Total import and export as percentage of GDP	Roine et al. (2009)
Top marginal tax rates	They are statutory top tax rates of a country. For UK and USA, we use the tax rates applicable for incomes higher than five times of GDP per capita, following Roine et al.	Roine et al. (2009)
R&D intensity	Research and development expenditure as % of GDP.	Madsen and Ang (forthcoming)*

* We are thankful to Professor Jakob Madsen for sharing his century long data on private credit and R&D intensity.

Table 4.A2 Summary of key variables

	Observation	Mean	St. dev.	Min	Max
Private credit	308	3.942	0.722	2.427	5.367
GDP per capita	308	8.905	0.730	7.072	10.260
Trade openness	253	3.527	0.727	-0.876	5.903
R&D intensity	308	-4.411	0.889	-7.594	-2.832
Top marginal tax rates	196	-0.858	0.637	-3.689	-0.025
Top 10% income shares	216	3.532	0.179	3.095	4.099
Top 5% income shares	266	3.157	0.236	2.572	3.720
Top 1% income shares	288	2.310	0.407	1.348	3.285
Top 0.5% income shares	225	1.971	0.472	0.801	3.019
Top 0.1% income shares	247	1.150	0.634	-0.572	2.589

Note: All variables are in logarithms

Chapter 5: Concluding remarks

This thesis examines the relationship between inequality and growth, inequality and financial development, and inequality and political instability in three separate chapters. It is indeed difficult to have a set of common conclusions for three such separate essays with distinct hypotheses. However, being integrated in the common perspective of determinants of income inequality, and its impact in shaping the economic and political outcomes across the countries, the findings of the thesis are to some extent interrelated.

As a whole it explores to answer the questions such as how today's inequality is connected to early development of our ancestors, or how colonization influences today's income distribution? It also answers how economic and financial developments are connected to inequality, measured by top income shares. Motivated by the observation that politically unstable countries tend to have wide income gaps, the second chapter of the thesis explores the possibility that major source of political instability is income inequality, which can be traced to the history of early development across the globe. Using data for 95 countries, the estimates provide support for the notion that before 1500 CE early development of our ancestors, and after 1500 CE evolution of institutions, and colonization, can explain today's income inequality, which subsequently affects the political stability of a country. Irrespective of the subsamples used, the results confirm pronounced impact of unequal income distribution on political instability.

The third chapter investigates the endogeneity between income inequality and economic growth, which seems to be impregnable in the literature. Motivated by Spolaore and Wacziarg's (2009) influential idea that genetic distance of population between countries put barrier to the diffusion of development, this work constructs weighted average growth of other countries as instruments for economic growth that can explain inequality across the countries. The weights come from genetic and geographic distances between two countries. Income growth per capita is instrumented to find growth's impact on the top income shares first, and then the residuals of the regression are used as instruments for the top income shares to identify the net impact of top income shares on economic growth in the subsequent regressions. Using top income data of fourteen OECD countries for around hundred years, the estimates provide support to the view that growth reduces top income shares; however, top income shares in turn enhances economic growth.

The fourth chapter explores the possibility of financial development as a major determinant of top income shares in the OECD countries. In a century long panel of time series data of top income shares and financial development, the work attempts to capture the impact of financial development on the income distribution of the top income strata. Couple of dynamic models has been used to check the robustness of our hypothesis in favour of financial development as a major source of rise in the top income shares. The results show that a one standard deviation increase in financial development, measured by private credit-GDP ratio, is associated with an increase of the top 1% income shares by around 0.3 standard deviation of its own. The effects are also robust to the other measures of top income shares and financial development.

Many efforts has been taken by the policy makers including redistribution to break the persistence of inequality in the society, as inequality is thought to be one of the causes of many negative social outcomes such as social instability, fragmentation in the ethnic, religious, or political lines, and even civil wars. Besides those efforts, inequality remains highly persistent till today. This thesis finds a strong connection between ancestral backgrounds and income of various groups in the current population of a country. For example, groups with higher state history (experience in and exposure to political states since the beginning of the Christian era) seem to have higher income in the populations of various countries. Critiques may argue that these sorts of findings are useless as it is not possible to change the ancestral background of an individual in a society to improve her current income. However, it is not impossible to reorganize the population of the society through migration of people from different ancestral backgrounds. It is also possible to take policies to improve the environment for interaction across various ethnolinguistic groups in the societies so that income variation through the channel of cultural heterogeneity diminishes. Therefore, appropriate policy mix considering migration and intercultural interactions such as frequent social gatherings, broader platforms for cultural exchanges can break the persistence of inequality through the channel of reduction of mistrust and inertia to exchange across the groups. Future works can investigate how cross-group income variation, social-political tension among groups, trust, etc. respond to a rise in social interaction between the groups.

Till today top income data are available mostly for the developed countries. However, the top income project of Paris School of Economics is preparing top income shares data for another 47 countries, most of which are the developing ones. As a result, the investigation of growth-top income and financial development-top income relationships carried out in this thesis can be extended to a worldwide sample comprising of more than 60 developed and developing countries. It will provide us with a generalized view of these relationships across the world on the one hand, and on the other more precise policy implication would emerge for both the developed and developing countries based on the identified differences in subsamples in terms of socio-political, cultural and geographic diversity. The future works can advance through this direction.

In the third chapter, we find a negative significant impact of top marginal tax rates on top income shares. However, in the fourth chapter, the impact seems to be insignificant. In practice, progressive taxation is a widely used tool to control widening income gap. Atkinson and Leigh (2013) find it effective for the Anglo-Saxon countries. Piketty (2014) also advocates in favour of progressive taxation to control the rise of top income shares. A future research could exclusively look into this matter as a natural next step of this study. Upcoming additional data for 47 countries from world top income database project will help to figure it out more precisely.

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Additional addendum

Page 8: Add at the end of para 1:

In the literature, the relationship between income inequality and political instability is debated for long. Most of the works find high association between inequality and political discontent, however the relationship remained a puzzle as both the positive and negative effect of inequality on instability is established in the empirical studies. On the other hand, they are not based on strong theoretical foundation. Lichbach (1989) reviews 43 earlier works and find the prevalence of both positive and negative relationships. Pioneers of positive relationship propose that instability is triggered by polarization of conflict participants (both the rich and the poor) in a highly unequal society. While rich are always at risk of losing their wealth, poor have nothing to lose. As a consequence, the poor demonstrates against the rich and the rich suppress the poor thereby increase instability (Alesina and Perotti 1996; Roe and Siegel 2011; Sigelman and Simpson 1977; Tanter and Midlarsky 1967; Gurr 1980; Prosterman 1976).

Others propose that the rich in a highly unequal society have sufficient social, economic and political power to hold down political unrest (Mitchell 1968; Nisbet 1968). Muller (1985) argue that political violence is a positively accelerated time-lagged function of income inequality. Davis (1954) and Nagel (1974) also find nonlinear relationship between inequality and instability. Some other proponents show that there is no or a weak relationship between inequality and political instability (Parvin 1973; Weede 1981).

Lichbach (1989) summarising earlier works conclude that most of the earlier works are statistical exercises without looking into the fundamental causes relevant to the relationship between inequality and instability as they do not illuminate the assumptions and reasoning that explain why and how inequality and instability are related. In fact, microfoundation of the relationship between income inequality and political instability has long been debated. Gurr (1970) suggests that political instability and conflict have roots in micro level. He argues that individual-level psychological processes are the transmission channels through which deprivation intensifies conflict behaviour in individuals. As a consequence, political conflict seems to be more prevalent in societies that suffer from highly unequal income and wealth distribution. He finds relative deprivation as a trigger of conflict behaviour in the individuals that ultimately reflects on political instability in societies.

In contrast, Olson (1965) predicts that conflict is not an outcome of socioeconomic and political discriminations, as rational individual will never rebel even if discrimination exists in the society because of the free-riding behaviour of individuals while working in a group. He argues that why should one bear the personal cost of participating in dissent if others who are not participating also reaping the same benefits. Accordingly, being a rational entity, no individual will participate in the rebel. He emphasizes free-riding behaviour of individuals that benefits at the cost of the others. Olson believes that the real explanation of instability lies elsewhere other than economic inequality. Thus the relationship between inequality and political conflict remains a puzzle as theories such as Olson’s collective action theory and Gurr’s relative deprivation theory are providing opposite views on the same issue. However, the relationship between inequality and instability exerts a better shape in 1990s.

Page 11: Add at the end of para 1:

Cultural theories proposed by Banfield (1958), Weber (1958) and Putnam (1993) suggest that collective action in societies are based on the beliefs they hold. Landes (1998), for example, identifies religion as a barrier to institutional development and a facilitator to spread instability in societies. Fractionalisation in societies in terms of religions in fact can have strong impact on political stability. Sometimes religious factions become so intolerant that one group may want to erase the identity of the others. A substantial portion of worldwide instability today also can be attributed to religious fractionalisation.

Fearon (2003) identifies 822 ethnic and ethnoreligious groups across the world. His ethnoreligious fractionalisation index reflects the probability that two randomly selected people from a given country belong to different such groups. Esteban and Ray (2008) and Esteban et al. (2012) in their work also use Fearon's ethnoreligious fractionalisation index. The index ranges between 0 and 1, from perfectly homogeneous to highly fragmented. We control Fearon's index as a proxy of fractionalisation as well.

Page 12: Add at the end of para 2:

In this study we use before tax income inequality measures. UNU-WIDER Gini index is used as the main measure of income inequality. However, WDI Gini index and Solt (2009) Gini index are also used for robustness checks. This work uses UNU-WIDER Gini index from UNU-WIDER World Income Inequality Database Version V3.0C (UNU-WIDER 2008), which provides high quality data as opposed to the earlier low quality data which was earlier criticised in the literature (for criticism, see Atkinson and Brandolini (2001)).

The benefit of using UNU-WIDER Gini index in comparison with other Gini indices is that (1) it provides more observations across countries (both for N and T), and (2) it is used widely as a measure of income inequality. Data for UNU-WIDER Gini index originally comes from Deininger and Squire (1996) (hereafter DS) dataset. It further includes data of new estimates from the Luxembourg Income Study (LIS), and some other new sources over time. At the same time, many low quality estimates were discarded from the original DS dataset mainly due to criticism from different sources.

In fact, no Gini index is flawless as they are derived from heterogeneous sources such as from surveys (mainly) and national accounts. Sometimes they are adjusted for timing of survey, income definition, etc. to make data comparable across the countries. The cross country inequality measurement mainly started in the 1990s with the compilation of DS dataset. Till today, 'UNU-WIDER World Income Inequality Database is the largest source of income inequality measurement used throughout researches.

On the other hand, Solt (2009) provides Standardised World Income Inequality Database (SWIID) that is widely accepted as a good measure of income inequality. Solt (2009) predominantly uses data originates from Luxembourg Income Study. He uses some standardization techniques to harmonize data from different sources given the variations in income source, income definition, etc. We use Solt (2009) Gini index for the robustness checks.

Page 29: Add at the end of para 1:

In column (6), we include Gini index in 1980s as an additional control. Inclusion of earlier decade's Gini index as additional control does not affect the main results. On the other hand, 1980s inequality only works through 1990s inequality on political instability.

Page 29: Add at the end of para 2:

Besides, in column (7) of Table 2.1 we control Fearon's ethnoreligious fractionalisation variable in our benchmark regression to test if our main proposition that inequality enhances political instability still remains significant when ethnoreligious fractionalisation is controlled for. The results do not affect the principal results.

Page 29: replace Table 2.1 with the following Table 2.1

Table 2.1 Least square estimates

Dep. Var. = State Fragility Index	(1)	(2)	(3)	(4)	(5)	(6)	(7)
UNU-WIDER Gini 1990s	0.18***	0.18***	0.18***	0.18***	0.21***	0.25***	0.16***
Beta coefficient	[0.45]***	[0.46]***	[0.45]***	[0.45]***	[0.52]***	[0.62]***	[0.42]***
	(0.043)	(0.043)	(0.045)	(0.044)	(0.042)	(0.066)	(0.040)
Hydrocarbon reserves per capita		-0.027	-0.032	-0.037	-0.035	-0.302**	0.029
		(0.074)	(0.074)	(0.078)	(0.079)	(0.136)	(0.079
Terrain ruggedness			0.232	0.217	0.113	-1.303**	0.209
			(0.313)	(0.294)	(0.294)	(0.537)	(0.283)
Landlockedness				0.214	0.381	-1.449	0.205
				(0.667)	(0.668)	(1.231)	(0.668)
Ethnolinguistic fractionalization	2.065	2.085	2.332	2.272			
	(1.845)	(1.823)	(1.861)	(1.872)			
UNU-WIDER Gini 1980s						-0.002	
						(0.043)	
Fearon's Fractionalisation index							2.97**
							(1.23)
Muslims	0.032***	0.031***	0.032***	0.033***	0.035***	0.058***	0.031***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)	(0.017)	(0.009)
Protestants	-0.031	-0.031	-0.031	-0.030	-0.030	-0.095***	-0.029
	(0.025)	(0.025)	(0.024)	(0.024)	(0.025)	(0.021)	(0.024)
Other religions	0.043***	0.043***	0.042***	0.042***	0.046***	0.160***	0.040
	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)	(0.019)	(0.012)
Constant	-9.32***	-9.44***	-9.69***	-9.74***	-10.05***	-9.25***	-9.14***
	(2.39)	(2.40)	(2.39)	(2.38)	(2.42)	(3.53)	(2.33)
Observations	94	94	94	94	94	30	92
R-squared	0.48	0.48	0.48	0.48	0.47	0.80	0.48

Notes: Beta coefficients are in the square brackets. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. Catholic is the omitted religion variable. 1980s Gini data are not available for many countries in this sample perhaps because only few countries in 80s undergo income surveys.

Page 30: Add at the end of para 1:

Apart from this, we use Lewbel (2012) technique as an alternative of our instrumental variable strategy. Lewbel's technique is based on the assumption that the data are heteroskedastic. We perform Breusch-Pagan/ Cook Weisberg test and Cameron and Trivedi's decomposition tests in this regard. The results cannot trace heterskedasticity in our data ($p<0.0005$).

However, we use Lewbel's internal instruments in the regression along with our external instruments. The external instruments seem to be robust in a linear combination with Lewbel's instruments. The results do not change remarkably as reported in column (8) in Table 2.2.

Page 30: replace Table 2.2 with the following Table 2.2

Table 2.2 Instrumental variable estimates

Dep. Var. = State Fragility Index	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) **Lewbel**
	Panel A: Second stage results							
UNU-WIDER Gini	0.33***	0.30***	0.35***	0.32***	0.36***	0.34***	0.35***	0.32***
Beta coefficients	[0.84]***	[0.76]***	[0.87]***	[0.82]***	[0.88]***	[0.84]***	[0.86]***	[0.80]***
	(0.06)	(0.07)	(0.08)	(0.06)	(0.07)	(0.07)	(0.06)	(0.06)
Observations	94	94	91	94	91	91	91	91
R-squared	0.34	0.42	0.38	0.40	0.38	0.40	0.39	0.42

Overidentification (p-value)				0.671	0.940	0.736	0.912	0.300
	Panel B: First stage results							
Absolute latitude	-0.38***			-0.32***	-0.33***		-0.26***	-0.25***
	(0.05)			(0.05)	(0.06)		(0.06)	(0.07)
Ethnolinguistic fractionalisation		19.16***		8.31**		14.34***	8.41**	9.37**
		(3.42)		(3.26)		(3.28)	(3.28)	(3.63)
Wheat-sugar ratio			-22.2***		-4.76	-17.3***	-5.41	-3.30
			(3.90)		(3.94)	(3.84)	(4.25)	(4.49)
R-squared	0.51	0.35	0.34	0.54	0.51	0.45	0.54	0.60
Partial R-squared	0.424	0.237	0.234	0.458	0.410	0.354	0.446	0.516
F-stat. (excl. instrument)	60.7	31.1	33.6	31.0	26.9	23.2	18.3	10.7

Notes: Beta coefficients are in the square brackets. Estimates of control variables and the constant in the regressions are not reported for brevity. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Page 36: Add at the end of para 1:

We also drop WSR as an instrument and run the same regressions with the two other instruments. The results do not significantly change once we drop WSR. They are reported in the appendix table 2.A4.

Page 45: Add at the end of Table 2.A3:

Table 2.A4 Alternative samples

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
	Exclude America	*Exclude Africa*	*Exclude low GDP per capita countries*	*Exclude high GDP per capita countries*	*Exclude low credit/GDP countries*	*Exclude high credit/GDP countries*	*Exclude low secondary enrolment rate countries*	*Exclude high secondary enrolment rate countries*
	Panel A: Second-stage results							
Beta coefficient (UW Gini)	**[0.72]*** **	**[0.85]*** **	**[0.68]*** **	**[1.61]** **	**[0.60]*** **	**[1.46]*** **	**[0.47]*** **	**[0.43]**
Overidentification P-value	0.554	0.605	0.424	0.084	0.972	0.069	0.621	0.098
	Panel B: First-stage results							
Absolute latitude	-0.264***	-0.325***	-0.399***	-0.110	-0.492***	-0.133	-0.324***	0.160
	(0.058)	(0.056)	(0.082)	(0.131)	(0.079)	(0.083)	(0.065)	(0.132)
Ethn. fractionalization	9.24**	5.98	9.25*	9.98**	6.72	8.63*	7.39**	19.7***
	(3.67)	(3.62)	(4.95)	(4.54)	(4.80)	(4.74)	(3.44)	(4.32)
Observations	75	71	46	48	46	48	49	45
R-squared	0.526	0.598	0.640	0.584	0.651	0.505	0.582	0.623
Partial R-squared	0.445	0.442	0.569	0.197	0.628	0.224	0.519	0.307
F-stat (first stage)	22.6	18.0	13.2	5.74	19.6	4.56	21.1	10.7

Notes: Beta coefficients estimates are reported in the square brackets. Estimates of control variables and the constant in the regressions are not reported for brevity. Robust standard errors are used. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. IV1=Absolute latitude and IV2=Ethnolinguistic fractionalization has been used as instruments for UNU-WIDER Gini index.

Page 77: Add at the end of Table 3.A3:

Table 3.A4 Robustness check using simultaneous equations method (3SLS)

	(1)	(2)
Dep. Var.	Top 1% income share	GDP per capita growth
GDP per capita growth	-0.387***	
	(0.097)	
Initial GDP per capita	-3.48***	
	(0.286)	
Top 1% income share		2.524*
		(1.443)
Educational attainment		0.400
		(2.475)

Patent application domestic		43.15
		(30.49)
Average tariff rate		-4.006
		(3.259)
First lag of growth		-1.782
		(1.217)
Second lag of growth		-1.554
		(1.187)
Constant	42.7***	-414.4
	(2.602)	(272.8)
Observations	273	273
First stage R-squared	0.653	0.422
Time FE	Yes	Yes

Notes: First lag of initial GDP per capita and first lag of growth are used as exogenous regressors in both the equations.

Table 3.A4 reports the results of the relationship between top income shares and economic growth in a system of simultaneous equations. The results are quite similar to our benchmark results provided in Table 3.1 and 3.2.

Column (1) reports impact of GDP per capita growth on top 1% income shares based on the specification in equation (2). The results are very similar to our benchmark regression results in column (5) of Table 3.1. Although the magnitude of the coefficient of growth seems to be large in the instrumental variable regression, the results in both the cases are significant at the 1% level.

Column (2) reports the impact of top 1% income shares on GDP growth. The coefficients are significant at the 10% level in the simultaneous equation method with the expected sign. However, in the instrumental variable regressions in Table 3.2, the results are significant at the 1% level.

The results obtained from the simultaneous equations method reinforce our results from instrumental variable approach in that while growth is reducing top income shares, the latter in turn is providing a higher income growth.

Page 89 Section 4.3.2: begins with the following paragraphs:

This work examines the impact of financial development (FD) on top income shares (TOP) in fourteen OECD countries. Historically, both the level of financial development and inequality are different across these countries. Galor and Zeira (1993) argue that in an imperfect capital market poor remain poor as they do not inherit sufficient fund to invest in their human capital (and also in physical capital.). The variation of imperfection in the capital market, which is deeply rooted in the evolution of the legal system and culture of the countries, is one of the main reasons for the FD-TOP relationship to vary from country to country. For example, the legal system of Anglo-Saxon countries—the British common law system—provides a culture of well-developed financial system in comparison with the French Civil law system (La Porta et al. 1997).

When we use a single “coefficient” to interpret the impact of X on Y, we essentially assume that the coefficient is the same across the countries. However, in reality, as countries are heterogeneous, the impact of financial development on top 1% income shares varies from country to country. In recent days, therefore, panel data analysis is moving toward a new era from assuming all the countries to have the same slope and intercept to the assumption of heterogeneity in both the slope and the intercept. Pioneered by Pesaran et al. (1999), the literature is heading to include the parameter and slope heterogeneity across the countries, and also include some other cross-country features such as cross-sectional dependence (Pesaran 2006; M. Eberhardt 2012). It is also heading toward capturing the dynamicity of the dependent variable in presence of intercept and slope heterogeneities as we used in our benchmark results (Chudik and Pesaran 2013).

The necessity of parameter and slope heterogeneity become evident in the macro-panel data analysis mainly because, unlike the micro-panels that typically has short T and long N, macro-panels now have long time series for each country for which country-specific slope and coefficients measurement is possible, and then average them to have mean group estimators. Parameter and slope heterogeneity can also follow a mixed process, where the countries are allowed in the short run to have varying slopes and intercepts, but constrained to have identical long-run coefficients (Pesaran et al. 1999; Pesaran 2006; Chudik and Pesaran 2013).

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