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**Public capital and income inequality: some empirical
evidence**

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Abstract

Economies vary in their reliance on public or private capital accumulation, and this variation has long been believed to lead to different distribution outcomes. In this paper, we take the share of public capital in total capital stock and public capital per GDP as the main explanatory variables. We then estimate the effect that capital ownership has on income inequality by using a panel data consisting of 145 economies in the period from 1980 to 2015. Our empirical results show that a higher ratio of public capital in total capital stock could lower the Gini coefficients of both original and disposable income distribution. Furthermore, we note that public capital per GDP is a sound measurement of public investment's accumulative contribution to the economy and find that it reduces income inequality, while private capital per GDP affects income inequality in the opposite direction. Accounting for the heterogeneity in development level, we further find that the negative effect that public capital has on income inequality is much more salient among low- and middle-income countries.

Keywords

Public capital, income inequality, redistribution.

JEL classification: H54, D31.

Public capital and income inequality: some empirical evidence¹

1 Introduction

In the past several decades, rising income inequality has been an alarming phenomenon in almost all parts of the world.² Indeed, income inequality has increased rapidly in both industrialized countries and developing ones since the 1980s (except that most Latin American countries, after recording the highest level in the world for decades, have experienced a mild decrease of income inequality since the beginning of the new century). Despite overall economic growth in most parts of the world, the living standards of the poor have stagnated and even worsened in some cases (Stiglitz, 2012; p18). Due to this rising inequality, the relevancy of using mean income to measure the living standards of the whole population has been called into question (Atkinson, 1997). Contrary to classical theories emphasizing inequality's positive impact on savings, investments, and, thus, growth (Kuznets, 1955), some recent studies in the literature have focused on market imperfection (Galor and Zeira, 1993), weak demand from the poor, capital outflow, and mechanisms of political economy to establish a negative association between inequality and growth (Aghion et al., 1999). Moreover, this new research has attempted to show that economic inequality is detrimental to other development goals. For example, Easterly (2007) notes that income inequality has driven underdevelopment, and Murshed and Gates (2005), using conflict data from Nepal, show that income inequality is the main contributor to internal conflicts. Due to the unwanted social and political repercussions of the rising inequality, governments and international organizations have put reducing inequality as one of the top priorities in their agenda.

The causes of income inequality have been studied at least since Kuznets (1955), and the early researches usually took a labor perspective. According to Kuznets (1955), wages would first rise in the manufacturing sector, causing the wage differential between manufacturing and other sectors to increase; wages in the service sector would then rise as the demand for service increases and the wage differential would narrow along with the economic development. Subsequently, as argued by Katz and Krueger (1991) among others, both the trend of the rising share of employment in the private sector and de-unionization could increase income inequality. Among the recent research on economic inequality, the rapid increases of the top decile/percentile income share in both OECD countries and other countries (Piketty and Saez, 2006; Roine et al., 2009) have been recognized as the most important component in the trend of rising inequality for the last several decades. While labors' allocation in the private and public sectors has been factored in, the equity effect of the allocation of capital in the private and public sectors has been under-investigated. As wage

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² See in the World Inequality Report (2018).

differentials resulting from the last information-technology-industry revolution have been insufficient in explaining the huge increase of top income shares, two other major driving forces for the last wave of rising inequality have been included: rising rents from private capital (Piketty and Saez, 2003; Piketty, 2015; Piketty et al., 2019) and institutional settings (Angeles, 2007; Chong and Gradstein, 2007; Milanovic, 2019).

Apart from the direct equity effect of private capital disparity (Piketty, 2015), the accumulation of private capital relative to public capital could affect income inequality through other mechanisms, namely, capital market imperfection, public goods investment, and the political lobbying by large private corporates and super-rich individuals. Capital market imperfection (Banerjee and Newman (1991); Galor and Zeira, 1993; Mookherjee and Ray, 2003; Piketty, 1997) has led to a lack of human capital investment of the poor, while the insufficient provision of public goods and infrastructure investment has deprived the production opportunity of the poor (Shell, 1966; Clarida and Findlay, 1992). The capital stock of an economy may affect tax and redistribution policies, as being the dominance interest of private capital, an increase in private capital stock would lead to much more lobbying for tax reduction and for less redistributive policies (i Vidal et al., 2012). Thus, the exclusively private-owned capital can usually transform into political disparity by establishing wealth-favored institutions and, as a result, political disparity could also materialize into economic disparity (Acemoglu and Robinson, 2008).

Due to the imperfection in the capital market, the pro-poor growth effect by infrastructure investment, and the counter-redistributive consequences of political lobbying by large private corporates and wealthy individuals, we hypothesize that a larger public capital presence in the economy could curb income inequality. We use two measures to gauge capital ownership, namely, public capital share (the ratio between public capital and total capital stock) and public capital per GDP. We also substitute the dependent variable with those from other data sources to conduct a robustness test and use different measurements of institutional quality to test the sensitivity of our model.

To the best of our knowledge, our work is the first to use capital stock data to estimate how capital ownership contributes to cross-country variation in income inequality. The most relevant work for our study is from Sturm and De Haan (2015); using a composite index of economic freedom from the Fraser Institute as an indicator of the capitalist economy, they test whether a capitalist economy or ethnolinguistic fractionalization would lead to more equitable income redistribution. However, their results are opposite to ours. They find that economic freedom does not affect market income inequality, whereas our results show clearly that a larger public capital presence has a consistently negative effect on market income inequality. They also find that, for countries with a low degree of fractionalization, a more capitalist economy could result in larger income redistribution; in contrast, we find no effect of capital ownership on income redistribution. The contradictory results of these two studies show that the metrics used to gauge the capitalist economy is crucial in determining the relationship between the capitalist economy and income inequality.

This paper is structured as follows: a brief literature review is given in section (2); this is followed by descriptive statistics of data and econometric method in section (3); we then show our main regression results and robust tests in section (4); finally, we offer our conclusions and further discussion in section (5).

2 Literature review

Several channels have been elucidated in theoretical studies regarding the nexus between capital ownership and inequality. Among the literature examining the nexus between public investment and inequality, infrastructure investment (consisting of most public investment) provides a large proportion. As for the literature on the association between public capital and growth (Romp and De Haan, 2007; Gupta et al., 2014), most theoretical studies treat public capital as an input in the Solow model or the AK model to examine the dynamics between public capital, growth, and distribution. Shell (1966) treats technical change as a public good that is produced by inventive activities, and Clarida and Findlay (1992) further emphasize the role of government in such inventive activity when government becomes the provider of education, research, and communication infrastructure, et cetera. With the view that public provision of education is believed to have a positive effect on equality, Glomm and Ravikumar (1992) find that public education contributes to the equality of human capital through an overlapping generational model in which the only inheritance is an educational investment that parents leave for their children. Chatterjee and Turnovsky (2012) integrated different financing paths of government spending on infrastructure into an AK model with heterogeneous agents, showing that government expenditure on infrastructure could increase wealth inequality over time; they concluded that although it could alleviate income inequality in the short run, it would exacerbate it in the long run. The underlying mechanism for this conclusion is that public infrastructure investment can enhance the productivity of private capital and thus encourage private capital investment with a distributional effect in favor of the already capital-rich people.

The second focus in the literature is on the market imperfection scenario, including asymmetric information, moral hazard, and the reverse selection problem, which gives rise to market failures in the credit market, insurance market, and labor market. Since Gertler and Bernanke (1989) connects the state of an agent's balance sheet to its ability to incur investment, scholars have extended the connection to understand how wealth distribution evolves along with different generations under market imperfection. In the utility function of these models, parents derive utility from the bequest they leave to their descendants; thus, an initial wealth inequality is embedded into the model by the choice parents make for the professions of their descendants. One stream of this literature is the occupational choice theory. Under the condition of indivisibility in investment, people without enough bequest from parents are unable to borrow money to invest in their human capital, both in an imperfect credit market (Galor and Zeira, 1993) and a missing credit market (Mookherjee and Ray, 2003); therefore, the initial wealth inequality persists through dynasties by different human capital investment from the parents. Furthermore, Banerjee and Newman (1991) model how differences in risk-bearing, which result from the different bequest of parents, could result in earning differences and even poverty traps in an imperfect insurance market. Piketty (1997) pointed out that credit market imperfection could lead to credit rationing and a differentiated higher interest rate towards capital-poor individuals compared to capital-rich ones. Matsuyama (2007) developed a simple and thorough model to examine

credit market imperfections' role on various economic issues, and he finds credit rationing acts as an "entry barrier" and thus contends that improvement in the credit market will benefit the middle class most.

Based on the models mentioned above, imperfections in the financial market lead to the absence of skill upgrading for the poor (Galor and Zeira, 1993), the persistence of wealth inequality (Piketty, 1997), and poverty trap (Banerjee and Newman, 1991). Public capital then enters into the discussion either directly by attenuated credit rationing or by lowering the expected bequest which is needed as collateral to invest in human capital or production. In these models, public investment has the advantage to compensate credit-constraints (Piketty, 1997) or the shortages of public goods (Ferreira, 1995) brought about by market failure. When market failure overweighs state failure because of capital market imperfection, the government is believed to have a comparative advantage in the provision of certain goods and services (Ferreira, 1995), such as infrastructure, education, and health services. Since the initial wealth inequalities could persist in the weakening of credit-rationing and the reinforcing of the insufficient provision of credit to the poor due to market imperfection (Piketty, 1997), the main advantage of public capital is to provide services under the situation of market failure and private-public capital complementarity (Ferreira, 1995). Furthermore, the association of larger credit market barriers and higher inequality is also supported by empirical evidence; Brückner et al. (2010) found a positive relationship between the income share of the top 1 percent and interest rate for the 20th century by using time series data from the US, the UK, and Sweden.

Another contributing mechanism through which public and private capital disparity affects income inequality has been the difference in the wage structure in the private and public sectors. Here, the inequality-reducing effect of the public sector has been widely researched.³ Among which the public sector displays much more inflexibility of wage-setting in response to market conditions and institutional changes. The reverse trend of unionization and the stagnation of minimum wage have been the main reasons behind the disparity of wage income in the private sector (Katz and Krueger (1991), which itself is the manifestation of the declining bargaining power of normal workers compared to big corporations and top managers. Katz and Krueger (1991) claim that changes in wage dispersion in the public sector show a contrary pattern compared to the private sector during the 1970s and 1980s in the US; whereas pay for white-collar workers in the public sector has been relatively stable, pay for blue-collar workers has increased dramatically in the federal, state, and local governments.

While there are a large number of empirical studies on the connection between public capital and growth (Aschauer, 2000; Gupta et al., 2014), there are no empirical studies on the direct connection between public capital and inequality. However, as a form of public capital stock, infrastructure stock has been tested for its equity effect. Lopez (2003) was the first to test the equity effect of infrastructure stock by using telephone lines per capita as an

³ See in the literature review of Lausev (2014).

instrumental variable for infrastructure stocks and controlling other growth determinants, such as human capital, financial development, and trade openness. He found that both infrastructure stocks and education have an inequality-reduction effect and are pro-growth, while other growth-enhancing factors, i.e. financial development, trade openness, and government downsizing, have a negative distributive effect. Calderon and Serven (2004) tested the impact of infrastructure stocks on growth and inequality, respectively by using a synthetic index of infrastructure stocks regarding both quality and quantity. They confirmed that infrastructure stocks consistently enhance growth and alleviate income inequality, with the quality of infrastructure stocks having a much more robust effect than the quantity of infrastructure stocks. A thorough review of the effects of infrastructure on growth and inequality can be found in Calderon and Serven (2014).

Change of public capital stock is mainly caused by public investment and nationalization (privatization). While public investment contributes to public capital accumulation gradually, nationalization (privatization) of corporates changes the relative size of the public sector vis-a-vis the private sector directly. Specifically, in many transitional economies, a large scale and rapid privatization of state-owned enterprises (SOEs) are pushed to expand the financial sector, and, as a result of such rushed privatization, inequality accelerates (Bildsall and Nellis, 2003). Milanovic and Ersado (2012) found that while privatization of large-scale enterprises is generally accompanied by the development of the financial market, such privatization tends to worsen inequality, whereas privatization of small and medium enterprises (SEMS) often generates anti-inequality factors by improving labor market conditions. In studies focusing on the collapse of the former Soviet Union and the privatization wave following it, it is noted that most of the benefits that come from privatization were captured by insiders in the post-communist former Soviet Union countries (Milanovic and Ersado, 2012; Alexeev, 1999).

In addition to our main explanatory variable, other macroeconomic indicators could also affect income inequality. Among those factors, financial development has been widely researched. Given the contention of the aforementioned theoretical models on financial market imperfections (Galor and Zeira, 1993; Piketty, 1997; Mookherjee and Ray, 2003) that the lack of access to the credit market has been the main cause of persistent inequality, financial development could linearly reduce inequality by expanding the coverage of financial services. However, according to the model of Greenwood and Jovanovic (1990), the effect of financial development on inequality also depends on the level of economic development; in the early phase of development, only the rich reaps the benefits of economic and financial development, while the poor can only have access to the financial market in the late phase of development. Empirical evidence regarding the effect of financial development on income inequality is also contradictory. Beck et al. (2007), using private credit to GDP ratio as an indication for financial development for around 70 countries in the period from 1960 to 2005, found that financial development has a direct negative impact on income inequality and poverty headcount. However, using an unbalanced panel dataset for a much larger sample of 138 countries, Jauch

and Watzka (2016) show that financial development exacerbates income inequality. Claessens and Perotti (2007,) reviewing recent literature on financial development and inequality, with a focus on access to finance, argue that initial inequality of wealth and political power could result in misallocation in the financial market, thereby favoring the rich and diminishing the poor's economic opportunity; thus, inequality becomes persistent. In the recent literature, financialization, a term referring to the expansion of the financial sector throughout the whole economy, has also been recognized as the main factor driving the rise of income inequality in the last 40 years as the financial sector has taken a comparatively larger portion of national income than other sectors (Dabla-Norris et al., 2015; Lin and Tomaskovic-Devey, 2013).

Moreover, political institutions are important because greater democracy has traditionally meant less plutocracy, but this may no longer hold in the current political climate of elected populist leadership. As the theoretical model developed by Meltzer and Ricahrd (1981) shows, the majority-vote system may result in a counterbalancing force towards rising income inequality. Robinson and Acemoglu (2000) developed a model based on the view that democratization anchors redistributive policies and decreasing inequality follows to prevent social unrest. By conducting reduced-form regression, Ressoin and Tabellini (2003) show that a well-established democratic institution could have a negative effect on income inequality. Recent studies (Angeles, 2007; Chong and Gradstein, 2007) have explored the effect of institutional settings on inequality, both theoretically and empirically, and have pointed out that weak institutional strength could entrench inequality. Acemoglu and Robison (2008) further modeled how the change in de jure political power can be offset by the investment in de facto power by economic elites. This means that they can increase their investment because the cost that elites are facing in a undemocratic institutional setting is much lower than in a democratic one, thus making a significant change of political institutions much more unlikely. Most recently, Milanovic (2019) argues that rising inequality in the United States is also resulting from the capture of political institutions by rich individuals, not just the traditional corporations, which renders a new kind of rentier capitalism different from the manufacturing capitalism of the Kuznets process. Beside those institutional indicators measuring democratic development, lower ethnolinguistic fractionalization is also associated with much more sizeable income distribution, especially in capitalist economies (Sturm and De Haan, 2015). Moreover, ethnic divisions have been proven to lessen the provision of public goods in both theoretical (Becker, 1957) and empirical research, from evidence both in developed (Alesina et al., 1999) and developing countries (Gershman and Rivera, 2005).

3 Data, summary statistics, and econometric methods

3.1 Data and descriptive statistics

In the paper, we use adjusted public capital stock data from “IMF Investment and Capital Stock Dataset, 2017”, which has been used by Gupta et al., (2014) to test the effect that efficiency-adjusted public capital has on growth. In this dataset, the public Investment management index (PIMI) from Dabla-Norris et al., (2012) is used to adjust public investment series in a perpetual inventory equation with the methodology adopted by Kamps (2006).⁴ Equation (1) is the inventory equation used to obtain adjusted public capital, in which δ_{it} is depreciation rate and q_i is the parameter of the efficacy index of public investment from PIMI.

$$K'_{it} = K'_{it-1} - \delta_{it} * K'_{it-1} + q_i * I_{it-1} \quad (1)$$

White elephant projects are a constant phenomenon among developing countries, which arouses doubt about the efficacy of public investment. Using public capital stock accumulated by public investment as a factor in growth decomposition and empirical research has been criticized by Pritchett (2000), Caselli (2004), and Robinson and Torvik (2005), since, compared to private investment, the efficiency of public investment is degraded more by severe agency problems. Treating public and private investment as the same regarding efficacy of capital formation makes no contribution to the understanding of economic performance and could be misleading in policy advising. Therefore, adjusting public investment by an efficacy index to accumulate public capital is necessary to measure the effect of public capital on economic growth and other macroeconomic performance like income inequality.

The data on inequality are from SWIID⁵ (Solt, 2016). There are two types of Gini coefficient given by the SWIID dataset, namely, the market Gini coefficient and the net Gini coefficient. The market Gini coefficient is calculated from the distribution of gross income, while the net Gini coefficient is derived from the distribution of disposable income after tax and redistribution. The data on GDP per capita (PPP adjusted) which is the annual growth of per person gross domestic production adjusted by purchasing power parity are from the World Development Indicators. Financial development is captured by domestic credit to the private sector (% of GDP) from the World Bank’s World Development Indicators. The data on institutional quality are from the Polity IV

⁴ The accompanying 2017 Update of the Manual "Estimating Public, Private, and PPP Capital Stocks"

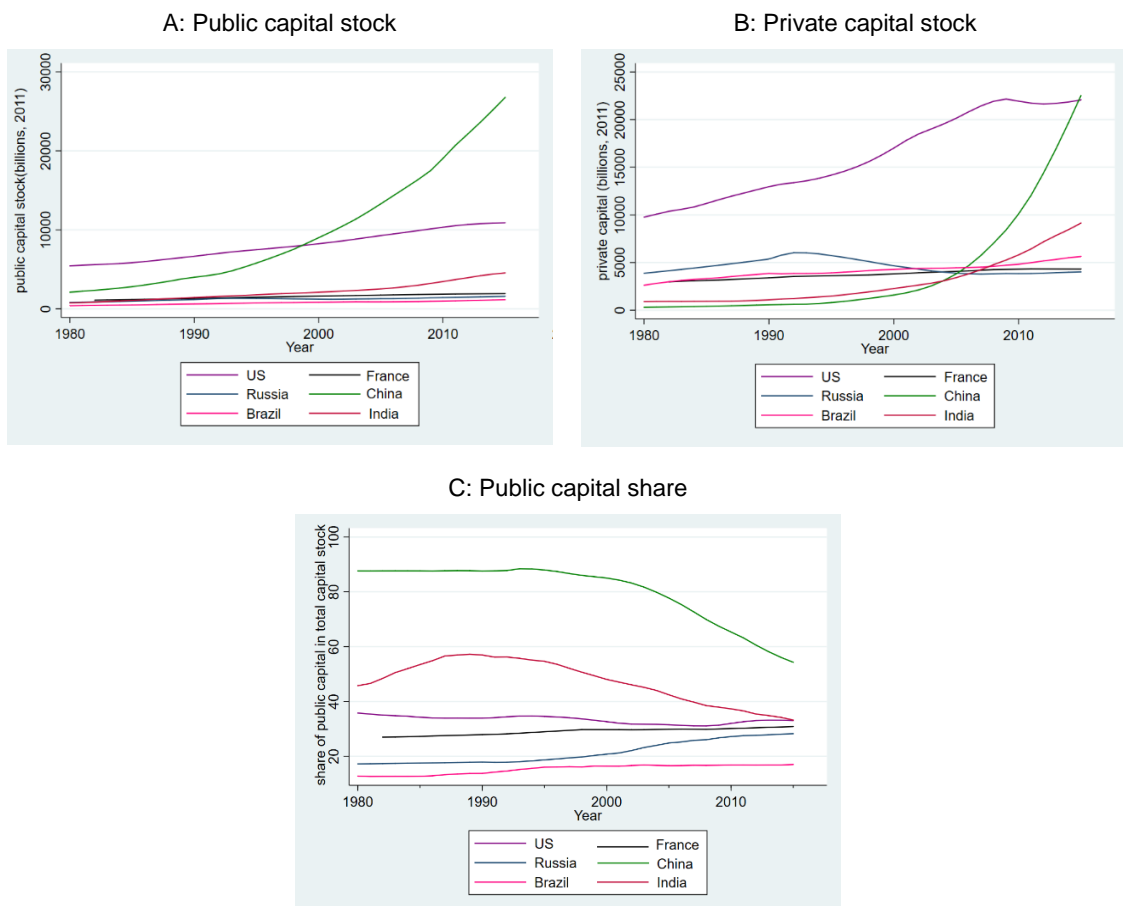
(<http://www.imf.org/external/np/fad/publicinvestment/data/info122216.pdf>) and IMF policy paper "Making Public investment more efficient"

(<http://www.imf.org/external/pp/longres.aspx?id=4959>) describes in great detail the series' definitions, the investment series' data sources, as well as the methodology in constructing the stock series.

⁵ Version 7.1 retrieved on 2-11-2018.

project (2017).⁶ The variable we use, Polity 2, gives the combined autocracy and democracy score of between -10 and +10, with +10 being the highest (democracy) and -10 the lowest (autocracy). The data on ethnic fractionalization and linguistic fractionalization (0-1 continuous scale) are from the QOG standard dataset (2018), and the source is Alesina et al., (2003).⁷ The legal origin data is from LaPorta et al. (2008). Countries are categorized into five groups by the origin of their legal system: English, French, German, Scandinavian, and Socialist. Because in our sample countries there is no country from the Socialist group (it only consists of North Korea and Myanmar), sample countries are grouped by the four that are left. We use the Scandinavian group as our baseline as the countries in this group are the most equal ones and thus, the effect that the other three legal origins have on income inequality can be compared with that of the Scandinavian legal systems.

Figure 1
Trend of public capital and private capital accumulation in selected countries



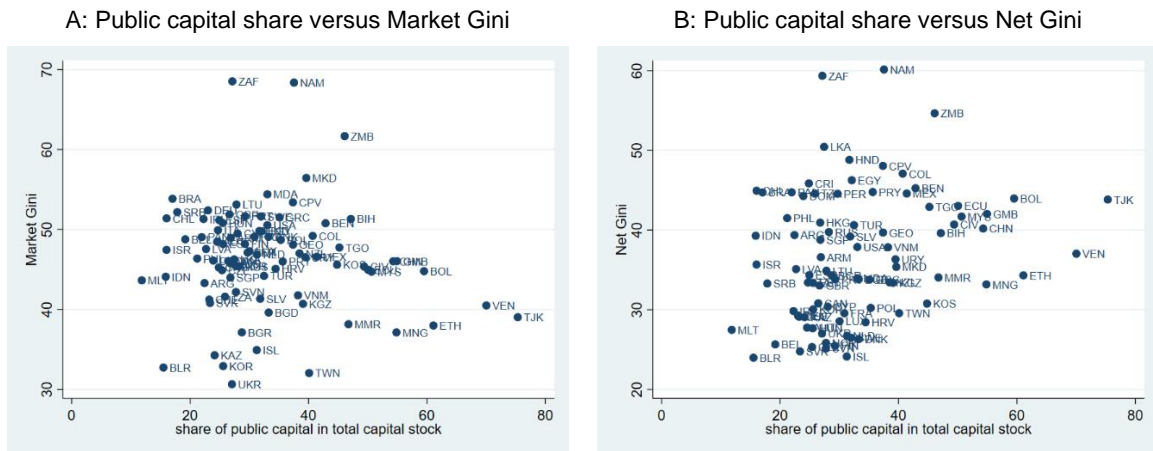
⁶ <http://www.systemicpeace.org/polityproject.html> retrieved on 25-2-2019.

⁷ http://www.anderson.ucla.edu/faculty_pages/romain.wacziarg/papersum.html

Firstly, we take a look at the trend of public and private capital accumulation in several major economies for the last several decades. From figure1, we can see that the trend for public and private capital accumulation is different between high-income countries and low- and middle-income countries. In developed countries, which are exemplified by the US and France, the accumulation of public capital and private capital is paralleled and the share of public capital in total capital stock has been stable over the last several decades; in developing countries with low economic growth in this period, strong public investment surpassed private investment and the share of public capital in total capital rose in that period; in developing countries, such as China and India, with high economic growth in the last several decades, accumulation of private capital dramatically out-paced accumulation of public capital, resulting in a huge drop of the share of public capital in the total capital. Overall, we were able to detect a conspicuous variation of the pattern of capital accumulation among these economies.

Then by simply plotting public capital share against Market and Net Gini using 2015 data in figure 2, we notice market Gini has a more discernible downward trend when the share of public capital increases. A more detailed analysis is needed when accounting for the effect of control variables and the heterogeneity because of development level.

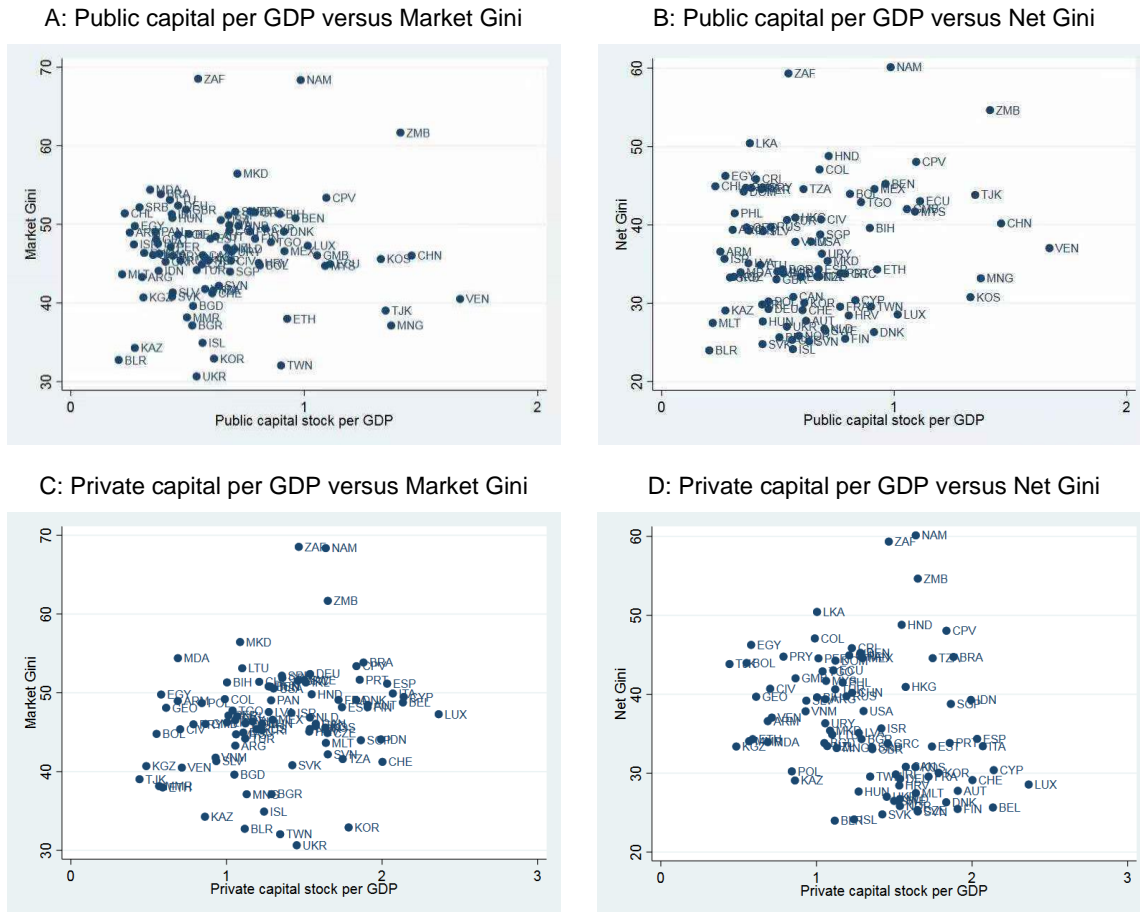
Figure 2
Public capital share against Gini coefficient (2015)



Note: Abbreviations correspond to 3-letter country ISO codes.

In figure 3, we plotted public/private capital per GDP against the Gini coefficient and note that the patterns of relationship between private capital per GDP against market Gini and net Gini are more discernible. Then we present the basic descriptive statistics of the variables in all regressions in table 1 and the correlation statistics of the variables used in our baseline regression model in table 2.

Figure 3
Public capital per GDP and private capital per GDP against Gini Coefficient (2015)



Note: Abbreviations correspond to 3-letter country ISO codes.

Table 1
Descriptive table

Variables	Mean	Standard Deviation	Minimum	Maximum
Market Gini	46.70	6.60	28.94	72.35
Net Gini	38.68	8.63	19.96	63.71
Redistributive ratio (%)	124.96	25.26	88.52	216.00
Labor share (%)	52.44	11.34	15.01	90
Income (constant 2011\$, ppp adjusted)	14419.36	16366.91	412.09	159009.6
Log Income	8.98	1.18	6.02	11.98
Public capital per GDP	0.791	0.679	0.024	7.242
Private capital per GDP	1.399	0.735	0.180	6.763
Public Capital share ratio (%)	35.40	15.84	8.44	88.61
Public Capital per capita (constant 2011\$, ppp adjusted)	10113.85	11452.42	65.41	75749.58
Private Credit ratio (%)	46.86	42.12	0	253.57
Broad money* (%)	63.77	461.53	1.77	18347.09
Institutions	4.26	6.26	-10	10
Ethnic Fractionalization	0.433	0.255	0	0.930
Linguistic Fractionalization	0.386	0.288	0.002	0.923
Electoral Democracy	0.567	0.268	0.021	0.940
Liberal Democracy	0.453	0.279	0.012	0.903
Participatory Democracy	0.369	0.214	0.011	0.834

Note: All descriptive values are for samples in column (4) of Table 3.

The metrics for all ratio variables are %.

* excessive value of broad money is excluded in our regressions in appendix 3.

Table 2
Correlation table

	Market Gini	Net Gini	Log Income	Public Capital Share	Private Credit	Institution
Market Gini	1.0000					
Net Gini	0.6443	1.0000				
Log Income	-0.0737	-0.4995	1.0000			
Public Capital Share	0.0125	0.2665	-0.3926	1.0000		
Private Credit	0.0034	-0.3449	0.6419	-0.2262	1.0000	
Institution	0.1356	-0.2556	0.4530	-0.2136	0.3723	1.0000

Notes: based on our baseline model, viz. samples in equation (4) of table 3.

3.2 Econometric methods

We have two baseline models in our regression: one to test the effect the public capital share of the aggregate capital stock has on income inequality, and the other one to test the effect of public capital per GDP on income inequality. In both models, the effects on market income inequality and net income inequality are tested, respectively. In our first baseline model, we use a reduced-form equation between income inequality, public capital share, income, and other variables mentioned in the literature review section to identify the effect of public capital share on income inequality, as shown by equation (2).

$$Gini_{it} = \alpha_1 KPubs_{it} + \alpha'_2 X_{it} + \alpha'_3 T_i + \epsilon_{it}, \quad (2)$$

Where i and t is the year and country mark irrespectively; *Gini* means Gini coefficient; *KPubs* means the the ratio of public capital stock of total capital stock; X is the vector for other control variables, including income level, financial development, and institutional variables; T_i is the year dummies; ϵ_{it} is the error term.

In our second baseline model, we use a reduced-form equation between income inequality, public capital per GDP, private capital per GDP, and other relevant variables to identify the effect of public capital share on income inequality, as showed by equation (3). Because there is a high correlation between GDP per capita and public capital per capita, GDP per capita is dropped from the control variables.

$$Gini_{it} = \alpha_1 KPubpg_{it} + \alpha'_2 KPrip_{it} + \alpha'_3 X_{it} + \alpha'_5 T_i + \epsilon_{it}, \quad (2b)$$

As for the techniques used in statistic models, fixed-effect OLS is applied for an unbalanced panel in our baseline model. As there might be an issue of omitted variables, the fixed effect model is fitted to give an unbiased estimation of the effect that our main explainable variables have on the dependent variable. In fixed-effect models, the means of all those unobserved country-specific variables are set to be non-random and the external shocks are captured by year dummies, giving the error term a good quality. Due to the limited inequality data in some countries, our panel data is unbalanced; as long as those factors behind the limited inequality data do not correlate with the error term, the result of fixed-effect regression is still unbiased. In the robustness test section, pooled OLS is used for those specifications with time-invariant variables. As both the dependant and explanatory variables are macroeconomic indicators, there is a concern about endogeneity in our regression model. However, the reverse causality from income inequality to public capital is less likely since capital stock is the result of cumulative processes of several decades preceding the income inequality that one observes for each year. In other words, the stock of public capital depends on the type of investment that has occurred several preceding decades in the past; therefore, it is more probably that public capital stock influences income inequality rather than having a relationship of the opposite direction.

4 Empirical results

4.1 The effect of public capital share on income inequality

Public capital share, the ratio between public capital and total capital stock, could imply how capitalist an economy is as it gauges directly the relative size of public investment and indirectly the relative size of the public sector in the economy. As shown in the literature review section, the public capital share could have an equity effect because of several factors: capital market imperfection, an inadequate provision of public goods by the private sector, and pro-business policy lobbyings by the private corporations. In table 3, we use the public capital share as our main explanatory variable to test its effect on market income inequality, net income inequality with country-fixed effects. Following Strum and De Haan (2015), we also test the effect of public capital share on redistribution in table 3.

Table 3
Fixed effect: effect of public capital share on income inequality

	(1)	(2)	(3)	(4)	(5)	(6)
	GiniM	GiniM	GiniM	GiniM	GiniN	Redis
Log Income	1.145 (0.906)	0.941 (0.987)	0.908 (0.961)	0.997 (0.951)	1.580** (0.784)	-1.53 (0.984)
Public Capital Share	-0.055* (0.029)	-0.063** (0.027)	-0.060** (0.027)	-0.065** (0.027)	-0.063*** (0.022)	0.026 (0.033)
Private Credit		0.024*** (0.005)	0.020*** (0.005)	0.021*** (0.005)	0.009** (0.005)	0.019 (0.012)
Institutions			-0.083** (0.038)	-0.179** (0.086)	-0.040 (0.029)	-0.079** (0.040)
PKxInstitutions				0.003 (0.002)		
constant	36.58	38.37	38.90	38.29	26.25	1.350
<i>N</i> (<i>N</i> of countries)	4053(158)	3838(157)	3635(145)	3635(145)	3635(145)	3635(145)
adj. <i>R</i> ²	0.144	0.168	0.174	0.179	0.131	0.062

Notes: GiniM means market income inequality; GiniN means net income inequality; Redis denotes redistributive ratio, which is the ratio between market Gini coefficient and net Gini Coefficient; PKxInstitutions is the interaction term between public capital share and institutions. Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Data from 145 countries (both developed and developing) during 1980–2015, the numbers of countries are in parentheses.

As shown in table 3, we find that public capital share has a consistent and significant negative effect on both market income inequality and net income inequality. Furthermore, the magnitude of the effect is quite stable when control variables are added sequentially from equation (1) to equation (3). The stability of the coefficients of public capital share from equation (1) to equation (3) shows that the association between the dependent variable and our main explanatory

variable is not sensitive to the typical specification. Overall, one standard deviation increase of public capital share could roughly bring down both the market and the net Gini coefficient by 1. For example, in 2015, Brasil's public capital share was 17%, one of the lowest in the World; if its public capital share had reached 41%, the level of Mexico in 2015, both the market and net Gini would have been brought down by 1.5, its market Gini would have been just below that of Germany (52.4) and net Gini would have been similar to that of Ecuador (43.0). In addition, we add an interaction term between public capital share and institutions in column (4) to see whether the impact of public capital on income distribution is conditional on the level of institutional quality; however, the interaction term does not present a significant effect. In equation (6), the effect of public capital share on the redistributive ratio is relatively small and not significant, which means public capital share does not have a discernible impact on redistribution.

As mentioned in the literature review section, the results for the effect of private credit on inequality have been contradictory (Beck et al., 2007; Jauch and Watzka, 2016). In the specifications above, private credit has a consistently positive effect on both market inequality and net inequality when controlling the ownership structure of capital. This means private capital formation and credit expansion will benefit the rich more than the poor. Such a positive effect is in line with the theoretical study of Mookherjee and Ray (2003), which emphasizes the pecuniary externality in private investment. In appendix 3, we show the results when substituting private credit/GDP by Broad money (M2/GDP) ratio as the measurement of financial development. When excluding extreme inflationary cases as Zambia experienced in the early 2000s and Estonia and Slovak experienced in the late 2000s (M2/GDP ratio exceeds 500%), we also note the expansion of money supply has a consistently positive effect on both market income inequality and net income inequality.

The mechanisms by which capital ownership affects income inequality might differ for economies in different development levels. We test the heterogeneity in table 4 according to the development level. Countries are classified into three categories (low-income developing countries, emerging markets, and advanced economies) in IMF Investment and Capital Stock Dataset (2017), and the methodology of classification can be seen in the IMF World economic outlook (April 2017)⁸. We further combine the low-income countries and emerging markets into one category: low- and middle-income countries, as those countries have both not been fully industrialized in the time span of our dataset and have an economic structure that is discernibly different from advanced economies.

When the sample is disaggregated into two subsamples according to income level, we note that public capital share exhibits a salient negative effect on both market and net inequality within the subgroup of low- and middle-income countries but not in the subgroup of high-income countries. As the extent of

⁸ <https://www-imf-org.eur.idm.oclc.org/en/Publications/WEO/Issues/2017/04/04/world-economic-outlook-april-2017#Summary>

credit rationing and public-goods shortage differs for developed and developing countries, the complementary effect of public investment on private investment and the welfare gains of the poor from public investment also vary. From the results, we can anticipate that the credit rationing and shortage of public goods investment are much more severe in developing countries than in developed countries and that the poor would benefit disproportionately from public investment in poor countries. Another reason for this disparity is that the political-economy dynamic is different between developed and developing countries. Whereas big corporations lobby for favorable policies in developed countries, political and economic elites tend to seek personal benefits through outright corruption in developing countries.

Table 4
Heterogeneity according to income level

	Low- and middle-income Countries		High-income Countries	
	(1) GiniM	(2) GiniN	(3) GiniM	(4) GiniN
Log Income	2.563** (1.208)	2.804*** (0.973)	-0.486 (1.835)	0.538 (2.039)
Public Capital Share	-0.089*** (0.024)	-0.077*** (0.021)	-0.064 (0.086)	-0.096 (0.074)
Private Credit	0.118 (1.05)	-0.124 (0.904)	-0.145 (0.732)	-0.171 (0.610)
Institutions	0.004 (0.030)	-0.000 (0.027)	-0.294* (0.160)	-0.150 (0.149)
constant	29.36	21.90	50.92	26.66
<i>N</i> (<i>N</i> of countries)	2627(113)	2627(113)	1008(32)	1008(32)
adj. R^2	0.148	0.180	0.594	0.311

Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The numbers of countries are in parentheses.

We also note that institutions only have a negative effect on the market Gini with a 10% significance level in high-income countries while the effect in low- and middle-income countries is almost null. However, the magnitude of the negative effect that democracy has on inequality in high-income countries has more than tripled than the coefficient of institutions on income inequality in table 3, indicating that a change from a totally authoritarian country (Polity IV score: -10) to a totally democratic country (Polity IV score: 10) could reduce the market Gini by an absolute value of 6 (0~100 range). For high-income countries, democracy has a significantly negative effect on the market Gini other than the net Gini, which implies that democracy affects income inequality through market regulations rather than distribution policies. A possible explanation for this is that in countries with well-established democratic institutions, regulations such as minimum wage could appeal to electorates, while redistributive policies face much stronger resistance from the public. For example, Bonica et al., (2013)

provide several reasons such as a shift of public opinion toward the deregulation of the economy to explain why, in the US context, a democrat system has not slowed the rising trend of inequality.

Since its inception, the Kuznets curve (Kuznets, 1955) has been the focus of studies on the evolution of inequality along the course of economic development. However, the reversed U-Turn Kuznets curve has failed to deliver itself. While the Kuznets curve held empirically as Kuznets observed the decline of both income and wealth inequality in industrial economies during the inter-war periods, recent empirical evidence shows much more ambiguity in the evolution of inequality over time. While Dollar and Kraay (2002) show that economic growth raises the income share of the lowest quintiles significantly, in recent research, van der Weide and Milanovic (2018), using US state-level data, show that inequality would enlarge the income of the already rich but reduce the income of the poor. The interpretation of the Kuznets curve has also changed (Atkinson, 1997). It no longer necessarily means a quadratic relationship between growth and inequality, but rather can be expounded as a dynamic of inequality's own evolution (Roine and Waldenstrom, 2015; p551): when inequality reaches a certain level, it would decline as the forces against it accumulate and are put into effect. Several studies (Barro, 2000; van der Weide and Milanovic, 2018) have shown that the association of inequality and growth is disparate between rich countries and poor countries, so we further test the existence of the Kuznets curve both for the complete sample and the separate samples based on income level.

From table 5, we could find a possible Kuznets curve for low- and middle-income countries in the period of 1980-2015, and the effect of growth on inequality is markedly larger for developing countries. The turning point is approximately 10.25 for equation (3) and 10.27 for equation (4), which means an income level of around \$ 28283 (PPP) in 2011 constant US\$. Since most countries in the low- and middle-income category have an income level below \$ 28283 (PPP), economic growth would increase income inequality. One of the reasons for this negative growth-inequality nexus might be rent seeking by the political elites, as many low-income economies had tremendous political inequality after independence, while economic inequality is currently relatively low because of low-level development. In the starting phase of development, extremely dominant political elites would reap the benefits of early development (Acemoglu, 2007), and huge political inequality would thus lead to economic inequality. The relationship between the ratio of public capital in total capital and the Gini coefficient (both market and net) is also stronger for developing countries, which is in line with the theoretical models (Galor and Zeira, 1993). As the capital market and legal institutions are under-developed in poor countries, those who do not have access to the private credit market can make use of public investment to utilize their economic opportunities. Financial depth and institutional indicators become insignificant from column (3) to column (6) in table 5 when the data are subsampled by income level. The explanation for this would be that developing countries are generally underdeveloped in finance and institutional settings and their variations are small, and consequently, they do not play an important role in determining inequality.

Figure 5
Test for the Kuznets curve

	All Countries		Low- and middle-income Countries		High-income Countries	
	(1) GiniM	(2) GiniN	(3) GiniM	(4) GiniN	(5) GiniM	(6) GiniN
Log Income	-4.557 (5.819)	4.090 (4.660)	14.63*** (5.581)	15.83*** (4.832)	-7.808 (22.41)	18.02 (21.81)
Log Income(sq)	0.315 (0.316)	-0.145 (0.255)	-0.714** (0.326)	-0.771*** (0.277)	0.367 (1.134)	-0.875 (1.129)
Public Capital Share	-0.062** (0.027)	-0.062*** (0.021)	-0.091*** (0.024)	-0.079*** (0.021)	-0.061 (0.087)	-0.103 (0.078)
Private Credit	0.018*** (0.005)	0.010** (0.005)	0.002 (0.010)	0.000 (0.009)	-0.001 (0.007)	-0.002 (0.006)
Institutions	-0.075** (0.037)	-0.044 (0.029)	-0.001 (0.030)	-0.006 (0.026)	-0.247 (0.202)	-0.262 (0.162)
Constant	62.37	15.47	-20.99	-32.42	86.96	-59.37
<i>N (N of countries)</i>	3635(145)	3635(145)	2627(113)	2627(113)	1008(32)	1008(32)
adj. R^2	0.178	0.133	0.171	0.214	0.594	0.317

Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The numbers of countries are in parentheses. The category of countries is based on the World Bank Countries and Lending Groups category (2017) by income level.

Since the basic Heckscher-Ohlin model predicts the dynamics of factor abundance and wage differential when economies turn from autarky to trade, the association between trade openness and inequality has been widely researched (Barro, 2000), nevertheless, with contradictory results. We test the effect of trade openness on inequality and find no significant effect of trade openness on income inequality (results are not reported here).

4.2 Public capital per GDP' effect on income inequality

As the results in table 3 show that a larger share of public capital results in lower income inequality, a more detailed analysis is needed to discern whether the negative effect comes from both public capital and private capital or just one of them. One metric that can be applied to gauge the effect of public and private capital separately is the per capita level of public/private capital. Besides the ownership type of capital, public capital owned per person may also matter as it means access to public goods and services. However, since economic growth is universally accompanied by the accumulation of public/private capital, the high correlation (0.8496) between income per capita and public/private capital per capita renders the empirical results in a reduced-form regression confounding.

Another metric could be the GDP level per public/private capital. As countries fall into similar development stages, this metric may display a very different composition of public and private capital, thus making the cross-country comparison much more reliable. While public capital share indicates the

degree of a capitalist economy, public capital per GDP reflects whether the contribution of public investment to economic development is plentiful or insufficient. In the following table 6, we find private capital per GDP has a consistently significant positive effect on income inequality, while public capital per GDP has a negative effect on income inequality, though not statistically significant. Compared to the accumulation of public capital, the accumulation of private capital in an economy drives up inequality. The result in table 6 corroborates the result we obtain in table 3. More specifically, this negative effect of public capital ratio on income inequality is attributed to the positive effect that private capital has on income inequality. This finding also aligns with the recent literature that emphasizes that the trend of rising inequality in the past several decades is partly attributed to private capital being able to obtain higher returns through international investments, while public investments are fixed domestically (Dabla-Norris et al., 2015).

Table 6
Effect of public/private capital per GDP on income inequality

	All Countries		Low- and middle-income Countries		High-income Countries	
	(1) GiniM	(2) GiniN	(3) GiniM	(4) GiniN	(5) GiniM	(6) GiniN
Log Income	1.129 (1.037)	1.811** (0.848)	2.898** (1.314)	3.089*** (1.054)	-0.325 (1.714)	0.779 (1.934)
Public Capital per GDP	-0.554 (0.449)	-0.623 (0.379)	-1.132** (0.446)	-0.931** (0.399)	-0.940 (2.083)	-1.425 (1.896)
Private Capital per GDP	0.770* (0.428)	0.845** (0.341)	1.476*** (0.371)	1.208*** (0.326)	0.592 (0.914)	0.896 (0.858)
Private Credit	0.020*** (0.005)	0.009* (0.005)	0.001 (0.011)	-0.001 (0.009)	-0.002 (0.007)	-0.002 (0.006)
Institutions	-0.089** (0.038)	-0.046 (0.029)	-0.001 (0.029)	-0.005 (0.026)	-0.315** (0.141)	-0.182 (0.142)
Constant	34.18	21.32	22.29	15.8	47.33	21.27
<i>N (N of countries)</i>	3635(145)	3635(145)	2627(113)	2627(113)	1008(32)	1008(32)
adj. R^2	0.168	0.123	0.147	0.174	0.592	0.303

Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The numbers of countries are in parentheses. The category of countries is based on the World Bank Countries and Lending Groups category (2017) by income level.

4.3 Public capital accumulation and functional distribution

Several studies (Gollin, 2002; Karabarbounis and Neiman, 2014) have noted a secular decline in the labor share of income since the 1980s. Most notably, Karabarbounis and Neiman (2014) model how the decline in the relative price of investment goods results in a rise in the capital-labor ratio in a production function stylized with constant elasticity of substitution (CES) when the elasticity of substitution between capital and labor is markedly above 1. As private capital mostly comprises industrial investment and public capital mostly comprises infrastructure investment and may have a different elasticity of substitution with labor, a different type of investment could affect labor share of income. Other studies (Quadrini and Rios-rull, 2015: P1258; Katz and Krueger, 1991) note loss of bargaining power as the main factor behind the decline of capital share. Here, we empirically test whether the relative size of the capital stock affects the labor share of income. We find that public capital share decreases labor share of income both in our overall samples and subsample consisting of developing countries in table 7. In high-income countries, there is a positive association between relative public capital size and labor share of income, but the effect is insignificant. We also test the effect that public/private capital per GDP has on the labor share of income, but no significant results have been found and the results are not reported.

Table 7
Public capital's impact on the labor share of income

	All Countries			Low- and middle-income Countries	High-income Countries
	(1)	(2)	(3)	(4)	(5)
	Labor share	Labor share	Labor share	Labor share	Labor share
Log Income	-2.406** (1.140)	-3.320** (1.398)	-3.242** (1.416)	-2.919* (1.716)	-1.753 (2.862)
Public Capital Share	-0.094** (0.045)	-0.090** (0.043)	-0.093** (0.043)	-0.11** (0.047)	0.020 (0.108)
Private Credit		0.023** (0.011)	0.026** (0.013)	0.011 (0.022)	0.030** (0.012)
Institutions			0.110 (0.079)	0.123 (0.089)	-0.200 (0.213)
Constant	78.16	85.89	84.83	80.12	77.28
<i>N (N of countries)</i>	4378(127)	4017(127)	3789(120)	2764(88)	1025(32)
adj. R^2	0.156	0.196	0.205	0.194	0.330

Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The numbers of countries are in parentheses. The category of countries is based on the World Bank Countries and Lending Groups category (2017) by income level.

Our result indicates that private investment is more labor-intensive than public investment. The reason behind the negative impact of relative public capital size on labor share may be found by applying the model developed by Karabarbounis and Neiman (2014). Thus, the reason could be that the elasticity of substitution between public capital and labor is larger than the elasticity of substitution between private capital and labor. According to the argument of Quadrini and Rios-rull (2015: P1258), another reason could be that larger public investment relative to private investment is related to the weakening of the bargaining power of labor. But we test the relationship between union membership (an indicator of labor bargaining power) and public capital share and find no significant association, which implies that bargaining power might not be the principal reason for the impact that we find in table 7.

4.4 Is there a top 1 percent effect of private capital accumulation?

Many recent studies on income inequality claim that the rising trend of income inequality worldwide is mostly attributed to the rapid rise of the income share of the top 1 percentile. As Piketty (2014) proclaimed, the accumulation of private capital since World War II is the main explanation for the latest trend of rising inequality on a global scale attributed to the $r > g$ mechanism. We test directly whether public capital accumulation is different from the accumulation of private capital in terms of its impact on the evolution of income distribution. We find that neither the relative size of public capital stock nor public capital per GDP has any effect on decile income share in the given dataset, although the coefficients change for different income groups (results presented in Appendix 4). We should note that the size of the sample in these two regressions is considerably smaller compared to the regression using the Gini coefficient Data provided by SWIID.

4.5 Robustness analysis

Our main identification strategy for econometrics is the focus on the entire effect, as our model captures the two main thrusts from capital accumulation to income inequality. Firstly, Piketty's argument that a relatively high portion of private capital results in increasing income inequality as the interest rate becomes higher than the growth rate. Secondly, Milanovic focuses on how wealth concentrates at the top and income inequality emanates from such wealth inequality. Moreover, since capital stock is an accumulative metric of preceding years' investments, it is reasonable to infer its causal effect on income inequality other than the opposite direction.

In this session, we use indicators of income inequality from another data source to validate the results of the former session, as well as substitute control variables of our baseline model with relative indicators to test the sensitivity of the relationship we find in the former sessions.

Table 8
Robust test: using the Gini coefficient and Palma ratio from World development indicator (World Bank, 2017)

	(1)	(2)	(3)	(4)	(5)	(6)
	GiniWB	GiniWB	PalmaWB	GiniWB	GiniWB	PalmaWB
Log Income	-0.231 (1.402)	-2.442 (8.791)	15.30 (21.62)	0.603 (1.386)	-4.572 (8.423)	26.16 (22.94)
Log Income (sq)		0.125 (0.491)			0.292 (0.470)	
Public Capital Share	-0.085** (0.041)	-0.086** (0.041)	-1.842** (0.729)			
Public Capital per GDP				-1.159** (0.538)	-1.222** (0.556)	-13.33 (11.44)
Private Capital per GDP				2.808*** (0.739)	2.839*** (0.719)	39.61*** (12.29)
Private Credit	0.032*** (0.011)	0.031*** (0.011)	0.668*** (0.180)	0.028*** (0.009)	0.027*** (0.009)	0.625*** (0.189)
Institutions	-0.082 (0.066)	-0.079 (0.066)	-0.832 (1.075)	-0.097 (0.065)	-0.090 (0.065)	-0.994 (1.046)
Constant	45.73	55.44	165.0	32.49	55.21	-38.89
<i>N</i> (<i>N</i> of countries)	1129(130)	1129(130)	1128(129)	1129(130)	1129(130)	1128(129)
adj. R^2	0.138	0.138	0.160	0.168	0.168	0.170

Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The numbers of countries are in parentheses. Palma ratio is the ratio of the income share of the top decile to the lowest 40 percent; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In table 8, we use the Gini coefficient and the Palma ratio from the World Development Indicators (World Bank, 2017) to replicate the main regression models in the last section to test the robustness of former results. These income inequality measurements derive from household survey data: while the Gini index indicates the overall income distribution after redistribution, the Palma ratio represents the ratio between the income share of the top 10% and the income share of the bottom 40%, which depicts the severity of inequality between the rich and the poor. From column (1) and (2) of table 8, we notice that public capital share displays a negative effect on the Gini index with roughly similar magnitude as in table 3. Additionally, in column (3), we note that the extent of the effect that public capital share on the Palma ratio is much stronger than the effect on the Gini coefficient, which indicates that accumulation of public capital can reduce the income gap between the top decile and the bottom four deciles remarkably. The relationship between public/private capital per GDP on the Gini index and the Palma ratio is much more robust in column (4) to (6) than the results in table 6, showing a strong equity effect of public capital per GDP compared to the opposite effect of private capital per GDP. Overall, although the SWIID coverage is almost 5 times more than that provided by the World Bank, and the sample size becomes only 1/3 of the former regression

model, the pattern and the sign of the relationship between the Gini coefficient and our main explanatory variables remain valid.

In table 9, we replicate our main results by substituting Polity 2 from the Polity IV dataset with Electoral Democracy, Liberal Democracy, and Participatory Democracy from the V-DEM⁹ dataset, which scores the different aspects of democratic practice from low to high (0-1). The results in table 9 are almost the same as we obtain in the last section, which implies that the main results are not sensitive to the institutional variable we use in regression models. By using segregated metrics of democracy from the V-Dem dataset, the association between strong institutions and equal distributions that we find from our baseline regression still holds. From Table 9, we notice that the various components of democracy have a consistently negative effect on the market Gini coefficient, with electoral democracy and participatory democracy (two of which enhance the majority voting system) at a 95 percent confidence level and liberal democracy at a 90 percent confidence level. Meanwhile, these three variations of democracy do not have a significant effect on the net Gini coefficient, as the direction of the effect is unchanged. Above all, democratic societies are more equal than undemocratic ones as a result of the market mechanism, but after redistribution of taxes and government transfer, the difference of income inequality between democratic and undemocratic societies shrinks.

Table 9
Robustness test: using various components of democracy

	(1)	(2)	(3)	(4)	(5)	(6)
	GiniM	GiniN	GiniM	GiniN	GiniM	GiniN
Log Income	0.939 (0.971)	1.563** (0.786)	1.001 (0.980)	1.598** (0.792)	0.973 (0.970)	1.580** (0.787)
Public Capital Share	-0.060** (0.026)	-0.062*** (0.022)	-0.060** (0.026)	-0.062*** (0.022)	-0.061** (0.026)	-0.062*** (0.022)
Private Credit	0.023*** (0.005)	0.012*** (0.004)	0.024*** (0.005)	0.012*** (0.004)	0.023*** (0.005)	0.012*** (0.004)
Electoral Democracy	-2.430** (1.109)	-1.229 (0.912)				
Liberal Democracy			-2.359* (1.216)	-1.334 (1.040)		
Participatory Democracy					-3.592** (1.757)	-1.797 (1.472)
Constant	39.42	26.75	38.61	26.36	39.05	26.56
<i>N</i> (<i>N</i> of countries)	3770(151)	3770(151)	3770(151)	3770(151)	3770(151)	3770(151)
adj. <i>R</i> ²	0.182	0.136	0.179	0.136	0.180	0.135

Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The numbers of countries are in parentheses.

⁹ <https://www.v-dem.net/en/data/archive/previous-data/data-version-8/>

Group dummies on Latin America and Sub-Sahara Africa have been widely used in regressions to determine the causes of inequality, and adding Anglo-Saxon origin of countries as a control variable has also been employed in the literature (Roine et al., 2009). Since the colonial origin and legal origin are highly correlated for those countries that have been colonized and the ambiguity arises when dealing with countries that have not been penetrably colonized, the legal origin can be a more convincing indicator for institutions when using cross-country panel data. In this paper, to obtain a much more covered grouping, we use legal origin (LaPorta et al., 2008) as the characteristic of the group dummy. Legal origin in former colonial land is mainly determined by the legal system of colonizers, and in those countries that have not been colonized, their legal origins are also highly related to the path by which they imported and implemented European legal systems. Usually, a certain region has the same legal origin due to their collective colonial history; thus, the aforementioned grouping per geography is captured by legal origin differences.

Table 10
Random-effects models: effect of public capital share on income inequality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GiniM	GiniN	GiniM	GiniN	GiniM	GiniN	GiniM	GiniN
Log Income	0.546 (0.794)	0.991 (0.725)	0.774 (0.816)	1.272 [*] (0.730)	0.882 (0.831)	1.331 [*] (0.739)	0.631 (0.802)	1.108 (0.717)
Public Capital Share	-0.059 ^{**} (0.027)	-0.059 ^{***} (0.022)	-0.057 ^{**} (0.027)	-0.060 ^{***} (0.022)	-0.058 ^{**} (0.026)	-0.061 ^{***} (0.022)	-0.059 ^{**} (0.026)	-0.059 ^{***} (0.022)
Private Credit	0.020 ^{***} (0.005)	0.009 ^{**} (0.005)	0.021 ^{***} (0.005)	0.010 ^{**} (0.005)	0.022 ^{***} (0.005)	0.010 ^{**} (0.005)	0.020 ^{***} (0.005)	0.009 ^{**} (0.005)
Institutions	-0.082 ^{**} (0.038)	-0.047 (0.029)	-0.087 ^{**} (0.039)	-0.050 [*] (0.030)	-0.089 ^{**} (0.039)	0.051 [*] (0.030)	0.080 ^{**} (0.038)	-0.044 (0.029)
Ethnic Fractionalization			4.904 (3.059)	15.45 ^{***} (3.346)				
Language Fractionalization					3.515 (2.703)	9.766 ^{***} (2.817)		
English Origin							6.376 ^{***} (2.327)	20.80 ^{***} (2.215)
French Origin							4.320 ^{**} (2.112)	19.38 ^{***} (1.759)
German Origin							-0.303 (1.835)	7.571 ^{***} (1.651)
Constant	41.97	31.70	37.60	22.25	37.25	24.51	37.06	13.00

Random-effect models with year dummies included in all equations, Robust standard errors in parentheses, ^{*} $p < 0.10$, ^{**} $p < 0.05$, ^{***} $p < 0.01$. The numbers of countries are in parentheses. Religious fractionalization has also been tested by the author, which shows it has less significant effect. There are four categories of legal origin, and Scandinavian legal origin is the baseline of our specification.

We further test our hypothesis with random-effects models in table 10; we replicate our baseline specifications in column (1) and column (2), and also add widely used time-invariant variables from column (3) to (8). In all those specifications, the coefficients for public capital share change marginally from results in fixed-effects models. All fractionalization indicators are positively correlated with income inequality, which aligns with theoretical models (Becker, 1957) and empirical studies (Alesina et al., 1999 and Gershman and Rivera, 2018). Moreover, ethnic and linguistic fractionalization have a much larger and significant effect on net income inequality, which is in line with the previous literature (Sturm and De haan, 2015) that shows ethnolinguistic fractionalization could stymie redistribution. When compared to Scandinavian countries, the legal system originating from Anglo-Saxon tradition has the largest positive effect on income inequality, followed by the French and German origin in sequence. It should also be pointed out that, similar to indicators of fractionalization, the effect of legal origin on net income inequality is notably larger than the effect on market inequality.

5 Conclusions

Our paper falls into the literature that uses market-structure differences among economies to explain cross-country variations in income distribution. In this paper, we set forth an empirical analysis of the association between relative public capital size and income inequality while controlling for financial development and institutional quality. The notion that a capitalist economy tends to be more unequal has a long history; however, our work is among the first ones to empirically test this hypothesis. Our main finding is that public capital has an equity effect when it is measured by its share in total capital stock rather than in absolute value accounted for by the total population. While public capital share has a consistently negative effect on both market and net income inequality, the difference between the effect of public capital on market income inequality and net income inequality is essentially negligible, which implies there is no redistributive effect of public capital accumulation. We find that public/private capital per GDP (as a measurement of the economy's reliance on public or private investment) has the opposite effect on income inequality, which could further explain the negative effect that public capital share has on income inequality. Thus, a capitalist economy has proved to be much more unequal, with the market mechanism playing a decisive role in such an association as the extent of the capitalist economy has almost no redistributive effect.

Moreover, our finding also has policy implications. While efficient-adjusted public capital could enhance productivity as the aforementioned literature shows, it has also proved to have an equity effect. Accordingly, a more accessible credit market for the poor can be created through public financing, and the government can provide public goods and invest in infrastructures. These measures could enhance the capacity of the poor to invest in themselves and engage in productive activities that would give rise to social mobility. Furthermore, in light of the ambiguity of the relationship between financial development and income inequality in the existing literature, we find that both private credit expansion and an increase of broad money would aggravate income inequality. This empirical evidence indicates that privatized financial development is not an optimal option for policy-makers to take when they try to avoid the rapid increase of inequality in the course of financial development. Further research can focus on how to improve the efficiency of public investment. The main limitation of this paper is that we were unable to estimate which income deciles benefit from a larger public capital presence in the economy due to data constraints.

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Appendices

Appendix 1 List of countries in our baseline model

Country name	Fre	Country name	Fre	Country name	Fre	Country name	Fre
Albania	17	Dominican Republic	30	Kyrgyzstan	20	Portugal	34
Algeria	24	Ecuador	29	Laos	19	Qatar	26
Angola	10	Egypt	36	Latvia	20	Russia	23
Argentina	34	El Salvador	25	Lebanon	2	Rwanda	29
Armenia	22	Equatorial Guinea	1	Lesotho	22	Senegal	21
Australia	35	Estonia	21	Liberia	10	Serbia	10
Austria	30	Ethiopia	14	Lithuania	20	Sierra Leone	32
Azerbaijan	17	Fiji	34	Luxembourg	27	Singapore	36
Bangladesh	29	Finland	34	Macedonia	22	Slovak republic	22
Belarus	22	France	33	Madagascar	33	South Africa	35
Belgium	33	Gabon	1	Malawi	33	Spain	34
Benin	14	Gambia	23	Malaysia	36	Sri Lanka	36
Bhutan	10	Georgia	21	Mali	16	Sudan	30
Bolivia	26	Germany	22	Mauritania	13	Suriname	7
Botswana	26	Ghana	27	Mauritius	26	Swaziland	25
Brazil	33	Greece	36	Mexico	36	Sweden	36
Bulgaria	25	Guatemala	34	Moldova	21	Switzerland	36
Burkina Faso	21	Guinea	8	Mongolia	21	Syria	11
Burundi	22	Guinea-Bissau	18	Montenegro	9	Tajikistan	15
Cambodia	16	Haiti	12	Morocco	27	Tanzania	28
Cameroon	19	Honduras	28	Mozambique	19	Thailand	34
Canada	29	Hungary	25	Myanmar (Burma)	6	Togo	11
Cape Verde	17	India	33	Namibia	13	Trinidad and Tobago	26
Central African Republic	17	Indonesia	36	Nepal	31	Tunisia	28
Chad	9	Iran	35	Netherlands	33	Turkey	29
Chile	36	Iraq	3	New Zealand	29	Uganda	22
China	29	Ireland	34	Nicaragua	22	Ukraine	23
Colombia	34	Israel	36	Niger	23	United Kingdom	27
Comoros	10	Italy	34	Nigeria	26	United States	36
Congo Brazzaville	7	Ivory coast	31	Norway	36	Uruguay	35
Costa Rica	36	Japan	35	Pakistan	34	Venezuela	34
Croatia	21	Jordan	29	Panama	36	Vietnam	20
Cyprus	31	Kazakhstan	21	Paraguay	26	Yemen	22
Czech Republic	22	Kenya	28	Peru	36	Zambia	29
Denmark	36	Korea South	36	Philippines	36	Zimbabwe	11
Djibouti	13	Kuwait	1	Poland	26		

Appendix 2
Data sources

Variable	Indicator	Data sources
GiniM	Market Gini, Gini coefficient of income inequality before taxes and transfers taken into account. The index ranging between 0 and 100, with larger values corresponding to more unequal income distributions	Solt(2009)
GiniN	Net Gini, Gini coefficient of income inequality (net of taxes and transfers). The index ranging between 0 and 100, with larger values corresponding to more unequal income distributions	Solt (2009)
Redistributive ratio	The ratio between GiniM and GiniN	Solt (2009)
Top One percent	The income share of the top 1 percent population in income distribution	Wid.world
Top Ten percent	The income share of the top 10 percent population in income distribution	Wid.world
Middle class	The income share of the 50 percent to 10 percent of the population in income distribution	Wid.world
Bottom half	The income share of the lower half of the population in income distribution	Wid.world
PalmaWID	Palma ratio of market distribution by using WID data	Wid.world
Labour share	Share of labor income in GDP	Penn world trade
Income	Real GDP per capita (purchasing-power-parity-adjusted constant 2011 US dollars)	IMF Investment and Capital Stock Dataset (2017)
Log Income	Natural logarithm of the Income variable	IMF Investment and Capital Stock Dataset (2017)
Public capital per GDP	Public capital stock (PPP-adjusted constant 2011 US dollars) divided by gross domestic product (PPP-adjusted constant 2011 US dollars)	IMF Investment and Capital Stock Dataset (2017)
Private capital per GDP	Private capital stock (PPP-adjusted constant 2011 US dollars) divided by gross domestic product (PPP-adjusted constant 2011 US dollars)	IMF Investment and Capital Stock Dataset (2017)
Public capital share	Public capital stock (PPP-adjusted constant 2011 US dollars) divided by the total of public capital stock and private capital stock (PPP-adjusted constant 2011 US dollars)	IMF Investment and Capital Stock Dataset (2017)
Private credit	Domestic credit to the private sector by banks (% of GDP)	World Bank (2017)
Broad Money	M2 (% of GDP)	World Bank (2017)
GiniWB	Gini coefficient of net income from World Development Indicators	World Bank (2017)
PalmaWB	Palma ratio of the distribution of net income from World Development Indicators	World Bank (2017)
Institutions	Polity 2 index (in the range between -10 to 10) from the Polity IV Project measuring the democratic accountability of the political system. Higher values corresponding to greater democratic rule	Polity IV project (2017)

Ethnic Fractionalization	Ethnic fractionalization index (0-1 continuous scale)	Alesina et al., (2003)
Linguistic Fractionalization	Linguistic fractionalisation index (0-1 continuous scale)	Alesina et al., (2003)
Legal Origin	The origin of the legal system is categorized by similarity as five groups.	LaPorta et al. (2008)
Electoral democracy	An indicator of electoral competition between political parties in a free election.	Varieties of Democracy (V-Dem) Project (2018)
Liberal democracy	An indicator of the extent to which individual and minority rights are protected against the tyranny of the state and the tyranny of the majority	Varieties of Democracy (V-Dem) Project (2018)
Participatory democracy	An indicator of the extent of active participation of the citizens in all political processes.	Varieties of Democracy (V-Dem) Project (2018)

Appendix 3
Broad Money (M2/GDP) as an indicator of financial development

	All Countries		Low- and middle-income Countries		High-income Countries	
	(1) GiniM	(4) GiniN	(2) GiniM	(5) GiniN	(3) GiniM	(6) GiniN
Log Income	1.616* (0.893)	1.944*** (0.738)	2.350** (1.006)	2.638*** (0.836)	1.077 (2.190)	1.722 (2.519)
Public Capital Share	-0.075*** (0.025)	-0.067*** (0.021)	-0.087*** (0.023)	-0.075*** (0.021)	0.043 (0.074)	-0.020 (0.080)
Broad Money	0.021** (0.010)	0.017* (0.009)	0.011 (0.016)	0.006 (0.014)	-0.006 (0.007)	0.009 (0.008)
Institutions	-0.063* (0.036)	-0.038 (0.029)	0.002 (0.030)	-0.001 (0.027)	-0.311** (0.135)	-0.243 (0.149)
Constant	33.69	24.83	30.71	23.01	30.71	12.72
<i>N (N of countries)</i>	3139(130)	3139(130)	2614(112)	2614(112)	525(18)	525(18)
adj. <i>R</i> ²	0.171	0.175	0.150	0.179	0.736	0.517

Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The numbers of countries are in parentheses. The category of countries is based on the World Bank Countries and Lending Groups category (2017) by income level.

Appendix 4
Is there a top income effect of public/private capital stock

A: capital ownership and decile income share

	(1)	(2)	(3)	(4)	(5)
	Bottom half	Middle class	Top ten	Top one	Palma Ratio
Log Income	-2.690*	-3.269*	5.783**	3.153**	0.616
	(1.474)	(1.694)	(2.347)	(1.400)	(1.023)
Public capital share	0.0259	-0.0453	0.0144	0.0523	0.0180
	(0.0534)	(0.0535)	(0.0828)	(0.0605)	(0.0499)
Private Credit	-0.0129	-0.00442	0.0122	0.00346	0.00715
	(0.0127)	(0.0166)	(0.0230)	(0.0175)	(0.00754)
Institutions	-0.137*	-0.0646	0.117	0.127	0.125
	(0.0767)	(0.0709)	(0.134)	(0.0937)	(0.0784)
Constant	43.78	71.65	-13.87	-19.97	-1.837
<i>N (N of countries)</i>	577(25)	577(25)	605(27)	619(27)	559(24)
adj. R^2	0.353	0.283	0.362	0.284	0.032

Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The numbers of countries are in parentheses. Palma ratio is the top ten percent income share divided by bottom 40 percent income share; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The decile income share data are from World Inequality Database¹⁰.

B: Public capital per GDP and decile income share

	(1)	(2)	(3)	(4)	(5)
	Bottom half	Middle class	Top ten	Top one	Palma Ratio
Log Income	-2.704**	-3.072	5.662**	3.058**	0.436
	(1.246)	(1.836)	(2.484)	(1.437)	(0.810)
Public Capital per GDP	-1.668	-2.044	3.489	2.496	1.707
	(1.259)	(1.871)	(2.284)	(1.469)	(1.103)
Private Capital per GDP	-1.220	0.965	0.123	-1.717	0.187
	(0.779)	(1.154)	(1.492)	(1.263)	(0.753)
Private Credit	-0.0147	-0.00510	0.0140	0.00492	0.00846
	(0.0116)	(0.0170)	(0.0226)	(0.0180)	(0.00630)
Institutions	-0.149*	-0.0612	0.115	0.127	0.128
	(0.0776)	(0.0674)	(0.136)	(0.0886)	(0.0782)
Constant	47.86***	68.39***	-15.13	-16.87	-0.993
	(12.02)	(18.21)	(23.13)	(13.27)	(7.281)
<i>N (N of countries)</i>	577(25)	577(25)	605(27)	619(27)	559(24)
adj. R^2	0.396	0.291	0.378	0.302	0.059

Robust standard errors in parentheses, country fixed-effects models with year dummies included in all equations, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The numbers of countries are in parentheses. Palma ratio is the top ten percent income share divided by bottom 40 percent income share; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The decile income share data are from World Inequality Database.

¹⁰ <https://wid.world>