Effects of Inequality on Growth: Aggravation from Aggregation?

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ABSTRACT

This paper demonstrates that empirical studies of the effects of inequality on growth that rely solely on macro data may provide misleading results. I provide a simple mathematical example that illustrates the effects of aggregating data from the level of the household in this case. I then explore the impact of income inequality on economic growth in rural China using both village-level and household-level data. Although the results obtained from village-level data find that inequality reduces growth, consistent with the macroeconomic literature, the results derived from household data tell another story: income inequality is positively associate to income growth for household with low initial income level. But such association will become weaker with the increase of household income. Such seemingly contradictory results agree with the predictions of my mathematical example and suggest that the political economy can explain the inequality-growth nexus in rural China.

JEL classification: O47; O15; E25.

Keywords: Income Inequality; Economic Growth; China; Aggregation Effect

1 Introduction

The impacts of income inequality on economic growth has long been one of core research interests among economists, politicians, or sociologists. Although the related studies on this line remains controversial, the notion of a trade-off between equity and efficiency seems deeply rooted in policymakers' consciousness, which is originally proposed in Okun (1975). From a perspective of policy makers, it seems that, to some extent, the goal of preventing income inequality from increasing and the goal of maintaining a sustainable economic growth are contradictive. Is it really the case? Related literature has been motivated to investigate the inequality-growth nexus. Interestingly, so far, the effects of income inequality on economic growth is still inconclusive. In terms of empirical studies, majority of them run a standard growth regression with a measure of income inequality as an extra explanatory variable with global data (see Alesina and Rodrik, 1994; Persson and Tabellini, 1994; and Clarke, 1995; Forbes, 2000; Barro, 2000). With different estimation techniques and various models, both positive and negative coefficients on income inequality are found.[1]

There are several drawbacks to the majority of the existing empirical literature in this area. Most of research focuses on global data, ignoring potential heterogeneity across countries/economies. Given the variation results across countries, policy makers need to ask whether particular conclusions may be applied to their countries. This question is especially critical after Barro's (2000, 2008) finding that income inequality has different effects on economic growth between poor and rich countries. These studies offer great examples to illustrate that failure in considering the degree of development will lead to a misleading general conclusion for all countries.

The second drawback relates to macro data (or aggregate data) that have been widely used to investigate the impacts of income inequality on economic growth. There are at least two potential issues that will affect the estimation result. The first

[1] Initially, Alesina and Rodrik (1994), Persson and Tabellini (1994), and Clarke (1995) conclude that the impacts of inequality on economic growth is negative. However, with introduction of the improved dataset and panel data estimation techniques, Forbes (2000) and Barro (2000) challenge the previous empirical evidence and find a positive inequality-growth relationship.

is that the previous literature pays little attention to the curvature of the growth function at the micro level. When testing whether economic convergence occurs across countries, traditional growth empirics normally assume that the economic growth is linearly correlated with the initial income level, ignoring the possibilities of curvature (such as quadratic or inverse correlation) at the micro level. This paper finds that different curvatures of the income growth function at the micro level will have different impacts on the marginal effect of income inequality on aggregate income growth. Specifically, if a quadratic term of initial income level is introduced to the micro growth function, then the association between income inequality and macro income growth will not necessarily to be negative. A mathematical example is offered to illustrate this issue in the next section. Another potential concern is the aggregating variables to produce macro data. Ideally, the macro data should be the algebraic mean of the micro index. However, aggregation effect will be arisen in the macro growth empirics. For example, economic growth of an economy, a core variable in this study, is the growth rate at the mean income per capita, not the mean of the growth rate of income per capita. Ravallion (1998) points out that aggregation effects in growth regressions at the macro level may severely bias conventional tests and generate spurious impacts of inequality on economic growth.[2]

Last but not the least, authors have put forward several explanations for why income inequality might impact economic growth: the credit market imperfection channel (see, Galor and Zeira, 1993; Banerjee and Newman, 1993); the political economy channel (see, Alesina and Rodrik, 1994; Bertola, 1993; and Persson and Tabellini, 1994); and the socio-political stability channel (see, Alesina and Perotti, 1994; Gupta, 1990; Perotti, 1996). However, there are few studies to support any of these transmission channels with their empirical results.[3] Wrong remedies might be implemented to deal with the trend of increasing income inequality if policy makers do not know how income inequality affects economic growth exactly. For example,

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[2] Ravallion (1998) investigates the impacts of asset inequality on consumption growth regression under the Cass-Koopmans-Ramseys framework at both household level and aggregate level. In his analysis, two assumptions should be met when examining the effects of inequality on growth: first, there is no underlying spatial externalities of average wealth; second, the change of consumption inequality should be white noise. Violations of these assumptions may lead to spurious effect of inequality.

[3] There are some exceptions. Perotti (1996) examine all discussed channels.

if the political economy is predominant, income inequality may retard economic growth in part because the efforts on redistribution caused by the unequal society themselves exert distortionary effects on growth. In this case, taxes and transfers may be exactly inappropriate policies (Ostry *el al.*, 2014).

In order to test the potential transmission mechanisms, micro data from a single country is needed. Due largely to the lack of such data, to the best of my knowledge, there is no such empirical work. This paper contributes to the literature and fits in this research gap. First, a mathematical example is provided to demonstrate the problems of aggregating data when ignoring the curvature of the micro growth function. Next, by using Chinese Household Income Project (CHIP) survey data, this paper verifies the predictions from the mathematical example. In addition, the current study will compare the estimation results both at the aggregate (village) level to the ones at the micro (household) level, in the hope of providing new empirical evidence for examining mainstream transmission mechanisms from a household perspective.

The estimation results show that at the macro level, a one percentage point increase in the Gini coefficient will lead to a 0.75 percentage point decrease in village income growth. At the micro level, empirical evidence shows that household income growth is a quadratic function of initial household income level and that no spill-over effect from village income inequality exists. Both results confirm the prediction from the mathematical example. In addition, combining the empirical results from both micro and macro level, it is suggested that the political economy channel is predominant in rural China.

The remainder of the current study is organized as follows. The second section provides a mathematical example and discusses how the specification of the micro growth function matters when investigating the inequality-growth nexus with macro data. The following section is a brief review of the mainstream transmission mechanisms of inequality-growth nexus, and discusses how they might apply to rural China. Section 4 describes the empirical strategy and discusses the predicted estimation results. Section 5 provides empirical evidence at both household and village level and discussion. The last part concludes and outlines policy implications.

2 Mathematical Example

In traditional growth empirics, it is normal to examine a growth function including a measure of initial income level on the right-hand-side in hope of examining the catch-up effect (or known as economic convergence). If the coefficient of initial income is statistically negative, it can be concluded that the growth for the poor is faster than their rich counterparts. However, the assumption that economic growth is linearly correlated to initial income might be too restrictive and ignore other shapes (or curvatures) of the growth function. If this assumption does not hold, the problem of misspecification regarding the growth regression may arise. This section provides a simple mathematical example to demonstrate this issue by introducing a quadratic term of initial income to the growth function. Other cases of different curvatures regarding the household income growth function are discussed in the Appendix C.

Suppose that in village *v*, there are only two households ($H = 2$) and each household has only one resident in every period ($n_1^h = n_2^h = 1$), therefore the total population (N^v) of village *v* is 2. The initial level of household income per capita for h_1 ($(y_1^h)_{-1}$) and h_2 ($(y_2^h)_{-1}$) are identical as Y. To monitor the impact of income inequality on economic growth, it is assumed that there is a mean-preserving income transfer from household h_1 to household h_2 by the non-zero amount of σ. After the income transfer, h_1 has $Y - \sigma$, while h_2 has $Y + \sigma$, enlarging the degree of income inequality ($Gini^v > 0$). It is worth noting that σ is standard deviation in this case, measuring the dispersion of household income per capita from the mean after the income transfer. The larger the σ, the more unequal in this village.[4]

Equation 1 is growth regression where g^h is defined as growth rate of household income per capita. For capturing catch-up effect, it is assumed that the coefficient

[4] Gini coefficient in this case can be computed as $\frac{\sigma}{2Y}$. It is clear that Gini coefficient is positively correlated to the standard deviation σ in this case.

on the level of initial household income per capita (α_1) is negative, which suggests that poor families will have relatively higher income growth rate compared to their richer counterparts. In addition, following Barro (1991), this model also allows for a quadratic term of initial household income per capita and assumes that the change of household growth rate will be slower with the increase in initial income level ($\alpha_2 > 0$).[5] Furthermore, for the purpose of simplicity, it is also assumed that there is no spill-over effect from income inequality at the household level, suggesting that the measure of income inequality does not enter the equation 1. This assumption will be verified in the empirical section of this paper.

$$g^h(y^h) = \alpha_0 + \alpha_1 y^h + \alpha_2 (y^h)^2 \, , \alpha_1 < 0, \alpha_2 > 0 \tag{1}$$

At the village level, growth rate of income per capita (g^v), conventionally, can be computed as the growth rate of the mean income per capita of village *v*. By plugging in all the settings and assumptions discussed above, after the income transfer, the village income per capita growth rate (equation 2) is not merely the growth rate of the mean household income per capita $g^h(\bar{y}^h)$, but also includes an extra term $\left(\frac{\alpha_1 + 3Y\alpha_2}{Y}\right)\sigma^2$.[6]

$$\begin{aligned} g^v &= \alpha_0 + \alpha_1 Y + \alpha_2 Y^2 + \left(\frac{\alpha_1 + 3Y\alpha_2}{Y}\right)\sigma^2 \\ &= g^h(\bar{y}^h) + \left(\frac{\alpha_1 + 3Y\alpha_2}{Y}\right)\sigma^2 \end{aligned} \tag{2}$$

To observe the relationship between σ and g^v, first order partial derivative with respect to σ has been practised as shown in equation 3. The computational result suggests that the sign of $\frac{\partial g^v}{\partial \sigma}$ depends on the curvature of the household growth

[5] Barro (1991) also relaxes the linear assumption of the growth function. Although the coefficient of the quadratic term is positive, it is marginally significant with the t-value of 1.4 only. In empirical result section of this study, the assumption of $\alpha_2 > 0$ is affirmed.

[6] $g^v = \frac{\Delta y^v}{y^v} = \frac{\Delta \bar{y}^h}{\bar{y}^h} = \frac{\sum_{i=1}^{H} \Delta y_i^h}{\sum_{i=1}^{H} y_i^h} = \frac{\sum_{i=1}^{H} (y_i^h \times g^h)}{\sum_{i=1}^{H} y_i^h} = \frac{\alpha_0(Y-\sigma)+\alpha_1 Y(Y-\sigma)^2+\alpha_2(Y-\sigma)^3+\alpha_0(Y+\sigma)+\alpha_1(Y+\sigma)^2+\alpha_2(Y+\sigma)^3}{Y-\sigma+Y+\sigma} = \frac{\alpha_0 Y+\alpha_1(Y^2+\sigma^2)+\alpha_2(Y^3+3Y\sigma^2)}{Y} = \alpha_0 + \alpha_1 Y + \alpha_2 Y^2 + \left(\frac{\alpha_1+3Y\alpha_2}{Y}\right)\sigma^2 = g^h(\bar{y}^h) + \left(\frac{\alpha_1+3Y\alpha_2}{Y}\right)\sigma^2$

function (α_1, α_2), and the size of the mean household income level (Y). To one extreme, if no curvature of growth function $g^h(y^h)$ in equation 1 is allowed ($\alpha_2 = 0$), the output ($\frac{\partial g^v}{\partial \sigma} = \frac{2\alpha_1 \sigma}{Y}$) of equation 3 will be a negative value, under the conditions that $\sigma > 0$, $Y > 0$, and $\alpha_1 < 0$. In other words, for the macro growth empirics, the conclusion of negative inequality-growth nexus might be purely caused by ignoring the non-linearity of initial income. Equation 3 clear shows that the marginal effect of income inequality on economic growth could be positive with a large α_2 or Y.

$$\frac{\partial g^v}{\partial \sigma} = \frac{2\sigma}{Y}(\alpha_1 + 3\alpha_2 Y) \tag{3}$$

One important insight from this simple mathematical example is that, misspecification of the household income growth function might lead to misleading conclusion regarding the relationship between income inequality and growth at the macro level. This brings about a concern on existing literature focusing on inequality-growth nexus with macro level data: the findings of negative impacts of income inequality on growth might be purely driven by the assumption that household income growth is linearly correlated to its initial income level. Alternatively, as explained in this mathematical example, the negative inequality-growth nexus might not exist once curvature of growth function is introduced.

3 Why Might Local Inequality Affect Household Income Growth

There are several transmission mechanisms to explain that how income inequality would have impacts on economic growth. In the first class of explanations, Alesina and Rodrik (1994), Bertola (1993), and Persson and Tabellini (1994) discuss the political economy that links income inequality and economic growth. At the macro level, the political economy channel works through political mechanism and economic mechanism. The first link illustrates that highly unequal income distribution would result in stronger needs for a higher redistributive tax rate in order to guarantee a more equal environment, which is mainly based on the median voter theorem proposed in Melzer and Richard (1981). Regarding economic mechanism, if policy makers levy a tax proportionally on one’s physical and human capital endowments directly to meet the need of redistribution, it will lower the after-tax return on individual investments. This would bring about lower rates of aggregate capital accumulation, therefore impeding subsequent economic growth. In other words, it is the redistribution and tax policies that impede economic development through its distortionary impacts on investment in physical and human capital. Hence, in this sense, together with the effects from both mechanisms, income inequality is predicted to be negatively associated to growth.[7] At the micro level, the redistribution policies caused by high inequality, might have different impacts depending on one's position of income distribution. Generally speaking, individuals who are located at the top of income distribution might be demotivated by the high tax rate because the after-tax return on individual investments will reduce significantly. Ideally, with the progressive taxation system, poor households will be better off trough the redistribution.

The second explanation that links income inequality and economic growth is the socio-political instability channel (Alesina and Perotti, 1994; Gupta, 1990; Perotti, 1996). Unequal income distribution generates strong motivations for people, who pursue their interests outside from normal market, to engage in rent-seeking activities and social disrupting behaviours such as revolutions, crimes, or coups. The resulting political and social instability increase production costs, reduce protection of property rights, and undulate investment environment, therefore exerting adverse impacts on economic growth at the macro level.[8] Also, socio-political unrest, caused by severe income disparity, might also result in greater pessimism for the future, therefore lead to less trust and social cohesion (Brown and Uslane, 2005). In this case, there will be more economic and social cost in economic activities, lowering productivity and economic efficiency, and therefore reducing economic growth. Similarly, at the micro level, high income inequality might redirect the resources to non-productive activities for the poor and the rich. For example, due to the fear from social unrest caused by high income inequality, the rich tend to invest more on security such as hiring body guards and lawyers. For

[7] Empirical evidence with cross-country data can be found in Perotti (1996).
[8] Further theoretical discussion of the interplay between the socio-political instability, levels of wealth, and motivation for capital accumulation can be found in Benhabib and Rustichini (1996), and Rodrik (1999).

the poor households, engaging in social disrupting behaviours also drive them away from normal productive activities, therefore deteriorating their income growth.

Several models (Galor and Zeira, 1993; Banerjee and Newman, 1993) emphasize the third transmission mechanism, which is referred as the credit market imperfection channel. Studies in this line stress that the cost of monitoring borrowers becomes higher due to asymmetric information in an imperfect credit market, which drives up the interest rate for borrowers. It is the stricter borrowing constraints in imperfect credit market that protect individuals, especially for the poor ones, from accessing to the loans against future income. If the initial level of inequality is high, then there will be more poor people who cannot assess to loans due to stricter borrowing constraints, therefore lowering the aggregate level of investment and human capital accumulation, and resulting in lower economic growth rate. At the micro level, the impoverished households have limit access to loans as the under developed credit market, might potentially be stuck in 'poverty trap' and therefore have lower income growth.

These are, by no means, the only explanations to reveal the potential effects of income inequality on economic growth. However, these mechanisms might play important roles in explaining inequality-growth nexus under the context of rural China to some extent. In principle, all three mechanisms could have been in effect. Village is at the lowest tier of the rural administrative rank and its government plays important roles in providing public services such as education, healthcare, and infrastructure, which heavily determines the living standard and local household income opportunities. From the perspective of the political economy explanation, inequality at the village level may put pressure on local government to tailor related village policies and therefore have effects on household income. Credit market imperfection might also be in effect as well. Although the economic reform since 1978 has brought about outstanding economic fruit, the credit and factor markets in rural area, so far, are still under developed (Benjamin, *et al.*, 2011). Regarding the socio-political instability, the unrest caused by inequality would cause waste of social resource and worsen the social cohesion, which is intuitive no matter at the village level or the national level.

4 Empirical Strategy

The previous empirical literature has found that income inequality is negatively associated to economic growth the macro level. However, through the mathematical example as discussed in section 2, the negative inequality-growth nexus might be invalid once certain level of curvature is introduced to the income growth function at the micro level. For instance, if the quadratic form of initial household income should be included in the household growth function, the impact from income inequality on aggregate income growth should be jointly determined by the degree of curvature and the initial averaged income at the micro level. To confirm this inference, the first task of this empirical research is to test the model (4), which is a household income growth function that contains both household income per capita and its quadratic form.

$$g_{i,t}^{h} = \beta_0 + \beta_1 y_{i,t-1}^{h} + \beta_2 {y_{i,t-1}^{h}}^{2} + \beta_3 Inequality_{j,t-1}^{v} + \beta_4 central + \beta_5 west + \varepsilon_{i,t} \quad (4)$$

g is growth rate of per capita income; y is the level of income per capita, the superscript 'h', stands for household level data while the subscripts 'i', 't' are the label for households and time, respectively. For instance, $g_{i,t}^{h}$ implies household income growth rate for household *i* at time *t*. In equation 4, it should be expected that $\beta_1 < 0$. This assumption is based on the economic convergence theory, also known as catch up effect in growth theory (Barro, 1991; Barro and Sala-i-Martin, 2004), which suggests that the growth rate for the poor tends to be faster than the rich. This is a common practice for majority of previous growth empirics (see, Barro, 2000; Forbes, 2000; Benjamin *et al.*, 2011). Corresponding to the mathematical example, it is assumed that β_2 should be a positive value, suggesting that the income growth rate will drop slower with the increase in household income per capita.[9] In addition, according to the mathematical example, it is also assumed that there is no spill-over effect from the income inequality at the village level, which implies that β_3 is expected to be not significantly different from zero. In equation 4, if both β_1 and β_2 are statistically significant and the corresponding signs

[9] This is also following the practice of the growth empirics in Barro (1991).

meet the expectations, it suggests that the linear assumption regarding the household income growth function is not appropriate. Furthermore, with the computed average household income per capita $\bar{y}^h$ and the estimated coefficients $\hat{\beta}_1$ and $\hat{\beta}_2$ in equation 4, the direction of impacts from income inequality to income growth at the village level can be predicted with the equation 3.

The second task of this paper is to verify this prediction via running regression 5 for two main reasons. First, it will offer a clear comparison between the estimation with data at different level (macro/micro) for the same specification. Second, due to the complex of non-linearity in equation 2, equation 5 offers a simplified version to monitor the association between the village income inequality and the village income growth. The research interest is focusing on the coefficient on the measure of village income inequality (γ_3). As discussed in the mathematical example, the sign of γ_3 should be the same as the computational result of $\left(\hat{\beta}_1 + 3\hat{\beta}_2 \times \bar{y}^h\right)$. Specifically, if the transmission mechanisms that are discussed in section 3 are in place at the macro level, it should be expected that γ_3 is negative.

$$g_{j,t}^{v} = \gamma_0 + \gamma_1 y_{j,t-1}^{v} + \gamma_2 {y_{j,t-1}^{v}}^2 + \gamma_3 Inequality_{j,t-1}^{v} + \gamma_4 central + \gamma_5 west + \varepsilon_{j,t} \tag{5}$$

Similarly, g is growth rate of per capita income; y is the level of income per capita, the superscript 'v', stands for village level data while the subscripts 'j', 't' are the label for village and time, respectively. The computation of g^v is the growth rate of the mean value of the household income per capita within that village (y^v), the practice which is in accordance with the definitions in the previous mathematical example.

The third task of this paper is to identify the transmission mechanisms, which is tested through the same regression at the macro level (equation 6) and at the micro level (equation 7), respectively. In addition to the equation 4 and 5, the new set of regressions (6 and 7) also include an interaction term of the household initial income and the measure of income inequality. If the abovementioned mechanisms are in place, it can be concluded that income inequality exerts adverse impacts on the subsequent economic growth at the macro level. In this case, the coefficient on the measure of income inequality for the equation 6 should be statistically significant and negative for all transmission mechanisms ($\theta_3 < 0$). However, to identify which mechanism is predominant, regression 7 should be of help. Based on the discussion in the section 3, given that $\theta_3 < 0$ in the equation 6, different coefficients on τ_3, τ_4 in equation 7 will inform a specific transmission mechanism. Table 4-1 has provided the related predictions regarding different transmission mechanisms.

$$g_{j,t}^{v} = \theta_0 + \theta_1 y_{j,t-1}^{v} + \theta_2 {y_{j,t-1}^{v}}^{2} + \theta_3 Inequality_{j,t-1}^{v} + \theta_4 y_{j,t-1}^{v} \times Inequality_{j,t-1}^{v} + \theta_5 central + \theta_6 west + \varepsilon_{j,t} \quad (6)$$

$$g_{i,t}^{h} = \tau_0 + \tau_1 y_{i,t-1}^{h} + \tau_2 {y_{i,t-1}^{h}}^{2} + \tau_3 Inequality_{j,t-1}^{v} + \tau_4 y_{i,t-1}^{h} \times Inequality_{j,t-1}^{v} + \tau_5 central + \tau_6 west + \varepsilon_{i,t} \quad (7)$$

If the political economy channel (model 1) is in effect in rural China, it indicates that the rich will suffer from lower growth rate while the poor will be better off through the redistribution caused by the high level of income inequality. In an extreme case, when one has zero initial income, then the interaction term should become zero as well. Therefore, the expectation of $\tau_3 > 0$ is to make sure this poor man is better off after redistribution. In the socio-political instability channel (model 2), the impacts of income inequality can be treated as negative externality since it is harmful to everyone regardless the position in income distribution. Therefore, if the socio-political instability is predominant, the sign on the coefficient of income inequality should be negative. However, the sign on the interaction term is uncertain since the exact impacts from income inequality to the rich and to the poor are unclear. If the imperfect credit market channel (model 3) is in place, then it should be expected that the coefficients on the measure of income inequality are statistically insignificant. As discussed in the credit market imperfection, the initial poor will be stuck in the poverty trap. In equation 7, since the initial household income has been controlled, if the coefficient on the measure of income inequality, it suggests that other factors besides imperfect credit market should be sources of the relationship.[10]

Table 1. Predictions for Different Mechanisms for Micro Regression

Model	Transmission Mechanisms	Expected signs
1	Political Economy	$\tau_3 > 0, \tau_4 < 0$
2	Socio-political Instability	$\tau_3 < 0$
3	Credit Market Imperfection	$\tau_3 = 0$

Note: Expected signs of the coefficients are referred to the equation 7.

Location dummy variables in all regressions are '*central*' and '*west*', with the baseline as '*east*', indicating the central China, Western China, and Eastern China, respectively. Consistent with most of the existing growth empirics on China, the provinces in three categories are demonstrated in Figure 1. The provinces in west of China are known as less developed areas, which are highlighted in dark in the Figure 1, while the richest regions, the east or the costal part of China, are coloured in light grey in the same figure. The remaining part should be the central China. It should be expected that the coefficients on location dummies are negative, indicating that both economic growth in western and central China are slower than the ones in eastern China.[11]

5 Data and Empirical Results

5.1 Data and Key Variables

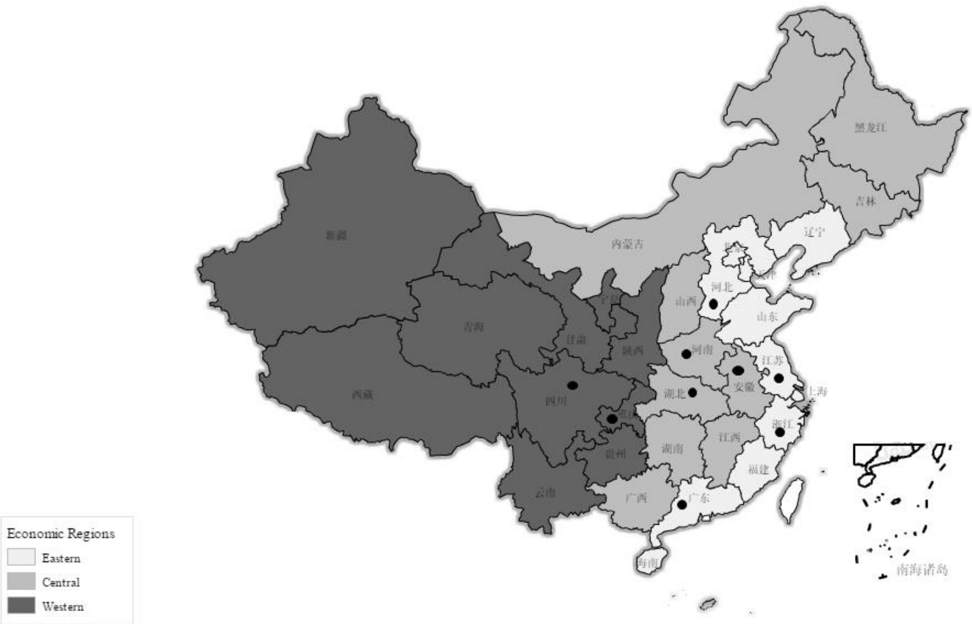
The data used in the current paper is mainly derived from CHIP, which was initiated by researchers from Beijing Normal University and Australian National University, and is supported by the China National Bureau of Statistics (NBS), and the Institute for the Study of Labour (IZA). The surveys were implemented by NBS

[10] This practice is also employed in Benjamin *et al.* (2011) for testing the imperfect credit market channel.

[11] Conventionally, Chinese provinces can be divided into three categories based on their economic development, namely western, eastern and central. The richest provinces are from the eastern of China, they are Beijing, Fujian, Guangdong, Hainan, Hebei, Jiangsu, Liaoning, Shanghai, Shandong, Tianjin and Zhejiang. The less developed provinces are from the western of China, they are Chongqing, Guizhou, Gansu, Ningxia, Qinghai, Sichuan, Shaanxi, Xinjiang, Xizang (Tibet), and Yunnan. The remaining provinces should belong to the central region, including Anhui, Guangxi, Henan, Heilongjiang, Hunan, Hubei, Jiangxi, Jilin, Inner Mongolia, and Shanxi.

through a series of face-to-face questionnaire-based interviews, covering both rural and urban areas in China in 1988, 1995, 2002, 2007, 2008, 2013. CHIP collects data at both individual and household level, including sources of incomes and expenditures, employment status, education level, and social and economic characteristics.

Figure 1. Economic Regions in China



Note: The provinces covered in the sample are marked by dots.

Even though six waves of CHIP are available already, I will use only CHIP2007 and CHIP2008 in this paper because the survey traced the same individuals and households in these two waves. This is of extreme importance since income growth, the dependent variable in equation 4, needs the information of the income level for the same households in each period. This requires panel data, instead of repeated cross section data. In this study, income growth is computed by the ratio between the change of income from 2007 to 2008, to the income level in 2007.[12]

[12] $growth = \frac{\Delta y}{y} = \frac{y_{2008} - y_{2007}}{y_{2007}} \times 100$, where y is the income level.

In addition, this paper will only employ data from rural China. For some transmission channels, there are significant differences between the rural and urban residents. For example, if I consider the whole sample combining both rural and urban household, the fact that the development of credit market in urban areas is significantly better than in rural areas will be ignored, and therefore may lead to misleading estimation results. All in all, data collected in CHIP2007 and CHIP2008 include more than 8000 rural households in each wave, covering about 350 villages from nine provinces in China. The selected provinces in CHIP2007 and CHIP2008 are marked as dots on the map in Figure 1, including Jiangsu, Zhejiang, and Guangdong from eastern China; Anhui, Hebei, Henan, and Hubei from central China; Chongqing and Sichuan from western China.

Before the estimation, several definitions should be further explained clearly. First, the definition of household in CHIP survey is based on Chinese residency and registration (hukou system). Second, regarding the definition of income, I will use gross income (e.g. wage income, income from family-run business) for each household member. Also, the calculation of income inequality index and income growth are based on the same definition of the household income per capita as well. With respect to the measure of income inequality, I will initially use Gini coefficients and then use Theil index and Mean-log-deviation as a robustness check for the estimation results.[13]

Table 2 provides the descriptive statistics including the mean, standard deviation, and quantiles of key variables at the household level (panel I) and village level (panel II), respectively. At the household level, except for the income per capita at 10th percentile, the income per capita in other positions of the distribution increased slightly. For example, the mean income per capita boosted from 5293 yuan in 2007 to 5924 yuan in 2008 (12% higher). It is worth noting that the poorest 10th

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[13] Gini coefficient is the most popular measure of income inequality, which is calculated by $Gini = \frac{1}{n}(n + 1 - 2(\frac{\sum_{i=1}^{n}(n+1-i)y_i}{\sum_{i=1}^{n} y_i}))$, where n and y are number of household for each village, and household net income per capita. The other two measures are from the generalized entropy measures, which can be formulated as $GE(\alpha) = \frac{1}{\alpha(\alpha-1)}\left[\frac{1}{N}\sum_{i=1}^{N}\left(\frac{y_i}{\bar{y}}\right)^{\alpha} - 1\right]$. α is the weight given to the distances between incomes at different parts of the income distribution. $GE(0)$ is mean-log-deviation and $GE(1)$ is Theil index in this paper. With a lower α, $GE(\alpha)$ becomes more sensitive to changes for the bottom percentile in the income distribution.

percentile, as shown in Table 2, has zero income per capita in both observed periods. This might be caused by the unresponsive interviewees. In other words, part of the interviewees did not report (or report only in one year) their income information. With respect to the income per capita growth rate, the mean is 110%, significantly higher than the 90th percentile of 96%. Further, considering this to the fact that the income growth rate for the 50th percentile is 0, it can be inferred that the growth rate of super rich (posited above 90th percentile) is high.

Table 2. Sample Summary Statistics

					Percentiles		
	Year	Mean	Std. Dev.	Obs.	10th	50th	90th
I. Household-level Data							
Income pc.	2007	5293.16	6781.58	7984	0	4500	12000
(Yuan)	2008	5924.77	7747.97	7971	0	4800	12600
Growth (%)		1.10	30.54	5528	-1.00	0.00	0.96
II. Village-level Data							
Income pc.	2007	5347.88	3725.79	355	1735.39	4700.00	9175.39
(Yuan)	2008	6071.89	5488.43	353	2089.93	4877.78	11384.62
Growth (%)		0.20	0.60	346	-0.32	0.08	0.84
Gini	2007	0.25	0.09	348	0.15	0.25	0.34
Coefficient	2008	0.26	0.10	347	0.15	0.26	0.36
Mean-log-	2007	0.14	0.11	348	0.04	0.12	0.25
deviation	2008	0.14	0.11	347	0.04	0.12	0.26
Theil index	2007	0.13	0.10	348	0.04	0.11	0.20
	2008	0.14	0.12	347	0.04	0.11	0.25

Note: The currency listed in this table is Chinese Yuan. The America Dollar (USD)-Chinese Yuan (CNY) exchange rate in 2008 was around 1 USD=6.95CNY.

Regarding the aggregate data at the village level, in general, income per capita in each category increased slightly from 2007 to 2008. However, the income distribution at the macro level seems more equal compared to the case with household level data. For example, income per capita for 10th and 50th percentiles are higher at the village level than the ones in household level, while the income per capita for the rich (90th percentile) at the village level is relatively lower. Similar pattern can be found regarding the village income growth rate. The mean of village income growth rate is about 20% annually. But the rich villages (the 90th percentile) growth much faster than the average level with the rate of 84%. With respect to the measures of income inequality, they show a slight increase from 2007 and 2008. The mean of Gini is around 0.25, indicating a low level (or acceptable level) of income disparity in observed sample. Gini is as low as 0.15 for 10th percentile, just less than half of the worst part, 0.34 for 90th percentile. Mean-log-deviation and Theil index show the similar trends.

5.2 Estimation Results

Table 3 summarizes the empirical results regarding equation 4 to 7, including the analysis at both micro and macro level. The empirical results of the robustness checks with different measure of income inequality are provided in the Appendix Table A-1 (with mean-log-deviation) and Table A-2 (with Theil index). Each column in Table 3 contains empirical results corresponding to their regression models that have been discussed in previous section. The first column contains the related explanatory variables for each regression, which is in accordance to their corresponding level of data (household/village). All results are derived from the ordinary least squares (OLS). For the regressions at the village level (equation 4 and 7), the standard errors are corrected by clustering the village. For better understanding the impact of income inequality on subsequent economic growth, variables of growth, and Gini coefficients are rescaled as percentage, and the unit for village income is in hundred Chinese Yuan.[14]

The estimation results for the regression 4 is shown in the column (i) in Table 3. The coefficients on $y_{i,t-1}^{h}$ and ${y_{i,t-1}^{h}}^{2}$ are statistically significant at 5% level and have the expected signs, suggesting that although the household growth rate will be lower with the increase of income, the rate of decreasing will be slower during this process. In addition, as assumed, the coefficient on the measure of income inequality is not significantly different from zero, implying that there is no spill-over effect from income inequality at the household level. As demonstrated in the mathematical example, since the household income growth function is not purely a linear relationship to initial household income, the association between income

[14] Since the value of income inequality lies between 0 and 1, it is common to use Gini coefficient as percentage in empirical studies. But in this paper, the mean-log-deviation and Theil index will not be rescaled.

inequality and income growth at village level might not be negative. According to equation 3, the sign of marginal effect of income inequality on growth should be jointly determined by the curvature of the household income growth function and the initial average household income. Given the results of equation 11 and the descriptive statistics in Table 2, it can be computed that $(\hat{\beta}_1 + 3\hat{\beta}_2 \times \bar{y}^h) < 0$, predicting that income inequality is negatively associated to the village income growth in rural China.[15] This prediction is verified by the equation 5, the results of which has been shown in column (ii) in Table 3.

Similar to the household income growth function, the growth function at the village level also shows certain concavity given that the signs on coefficients γ_1 and γ_2 are the same as the ones in β_1 and β_2, and are statistically significant at even 1% level. The research interest is focusing on the coefficient of income inequality measure, which is -0.75 and significant at 5% level. It implies that about one percentage point increase in Gini coefficient is associated to 0.75 percentage point decrease in village income growth. Such adverse correlation confirms the prediction computed with the household level estimation results. Also, this finding supports the previous empirical literature. It is worth noting that from the estimation results both equation 4 and equation 5, not all location dummies have expected empirical results. While the coefficient on central is not significant at all, the coefficients on west are negative and significant, indicating that the income growth in central rural China and eastern rural China has no different but the one in western area is significantly lower.

Given the estimation results from equation 5 that income inequality is adversely correlated to village income growth, the next question is: which transmission mechanism could potentially explain this inequality-growth nexus in rural China? The last two columns of Table 3 are estimation results for the regression 7 and 6, respectively. At the village level, with the additional interaction term between income inequality and initial income per capita in equation 6 (column iv), the empirical results do not change significantly compared to the ones in regression 5. However, the interaction term is not significantly different from zero, suggesting

[15] $\hat{\beta}_1 = -11.188, \widehat{\beta_2} = 0.030, \bar{y}^h = 52.9$

that the negative impacts of income inequality do not vary with the development of the village. At the household level (column iii), the coefficient on the measure of income inequality is positive while the one on the interaction term is negative, suggesting that village level income inequality is actually in favour of the poor household, but harmful to the rich. Both coefficients are significant at 10% level. In general, both results of regression 6 and 7 show that the growth rates in western China are significantly lower than the ones in eastern China, but there is not significant difference between central China and the eastern. Combining the empirical results from regression 6 ($\theta_3 < 0$) and regression 7 ($\tau_3 > 0, \tau_4 < 0$), it seems that the theories of political economy channel is potentially predominant when explaining the negative inequality-growth nexus in rural China.

Table 3 Estimation Results for Model 11 - 14

	Inequality Measure: Gini Coefficient			
Independent Variables	(i)	(ii)	(iii)	(iv)
y_{t-1}	-11.188**	-0.880***	-4.447*	-1.099***
	(4.443)	(0.168)	(2.411)	(0.240)
${y_{t-1}}^2$	0.030**	0.003***	0.038**	0.003***
	(0.012)	(0.001)	(0.016)	(0.001)
$Inequality_{t-1}^v$	6.311	-0.750**	28.448*	-1.175**
	(4.181)	(0.359)	(15.591)	(0.488)
$y_{t-1} \times Inequality_{t-1}^v$	-	-	-0.286*	-0.008
			(0.156)	(0.006)
$central$	-0.387	-7.673	-0.901	-7.352
	(105.412)	(7.100)	(105.551)	(7.097)
$west$	-181.229**	-18.689**	-174.08**	-17.949**
	(88.891)	(8.689)	(86.203)	(8.699)
Constant	567.116**	81.632***	-14.093	92.902***
	(224.965)	(11.104)	(233.628)	(14.149)
Data Level	Household	Village	Household	Village
Equation	4	5	7	6
R-square	0.007	0.108	0.009	0.113
N	5528	346	5528	346

Note: Standard errors are reported in brackets. *** Significant at 1 percent level. ** Significant at 5 percent level. * Significant at 10 percent level. Household (village) in Data Level row indicates the regression are examined with household (village) level data. The standard errors are corrected by clustering the village and are shown in the parentheses for the estimations at the household level. The dependent variable is growth rate of income. Both growth rate and Gini coefficients are rescaled in percentage while the income per capita is rescaled in hundred.

5.3 Discussion

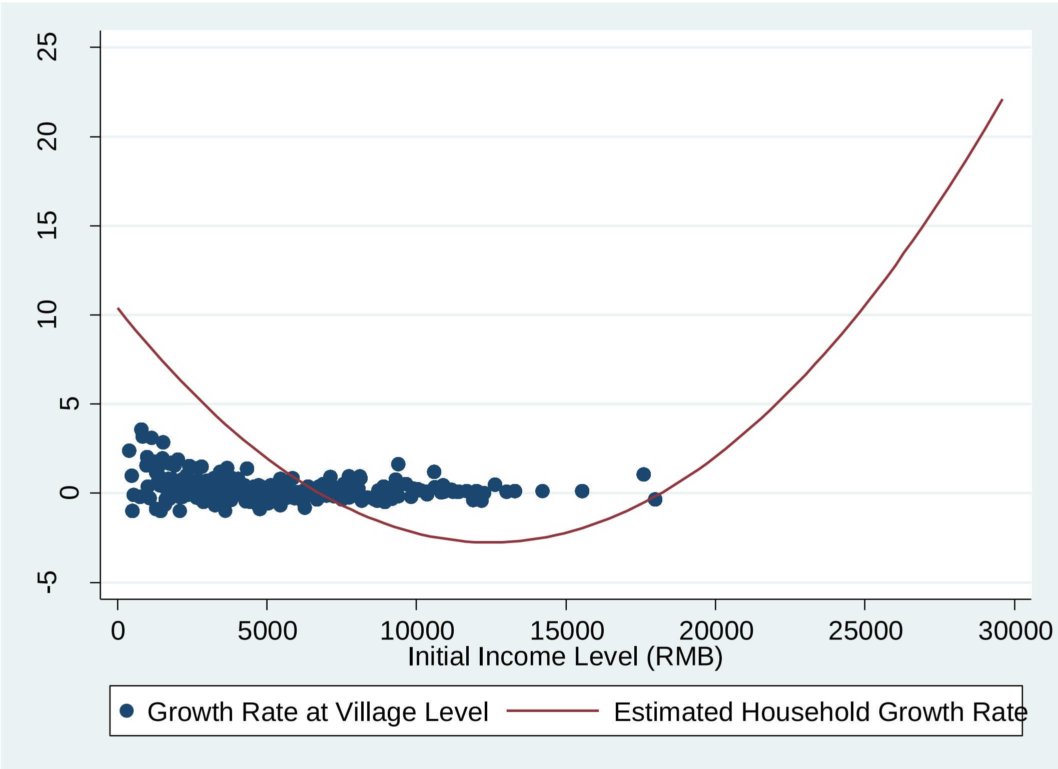
It is obvious that estimation results from micro and macro level regressions are inconsistent: while the macro regression shows that income inequality is negatively associated to the subsequent income growth, the micro regression results do not support this finding with household data. If a policy maker solely believes in the results derived from macro empirical evidence, he/she will make completely wrong remedies against income inequality.

Why are the outcomes so different? One possible explanation is aggregation effect. Ravallion (1998) is the first study to point out that macro data might misreport the true relationship and generate spurious impacts of inequality on growth. In this paper, aggregation effect will be in place when macro data is not purely the mean value from the micro data. These variables, in current study, include the squared initial income per capita, and income growth. Appendix B has illustrated how growth rate at the aggregate level and aggregate squared initial income level are not simply the mean of their micro corresponding values.

To demonstrate the aggregate effect, figure 2 depicts the differences in growth rates with macro and micro data. The horizontal axis is the level of initial income per capita while the vertical axis is the income growth rate. Particularly, the dots in figure 2 are the income growth rate for villages against its corresponding initial village income per capita. If the household initial incomes are identical across village (the extreme income equality), then the growth at the macro level is exactly the mean of the growth income. In other words, if there is no initial income variation in the villages, then the dots in the figure 2 should be on the quadratic fit of the household income-growth function. In this case, then aggregating the data at the macro level would not cause any trouble.

The aggregation effect will arise when there are variations of initial income among households. As shown in the figure 2, the economic growth at the village level (shown as blue dots) are spreading around zero and less diverse because the household income variations are averaged at the macro level. In addition, it is also worth to note that the blue dots (village economic growth rates) are not always lower than the predicted household income growth, implying that the actual direction of the error when aggregating the household level data is uncertain.[16] It is suggested in the figure 2 that the village economic growth is overall lower once the household level income is aggregated because the majority of the dots are laying under the predicted household income growth. This will be mistakenly counted as the adverse impacts of income inequality, if policy makers do not realize the existence of aggregation effect. As a result, the negative impact of income inequality on economic growth (if it exists) might be amplified by aggregate effect.

Figure 2. Actual Village Growth v.s. Predicted Household Growth



Note: The scatter plots are the income growth rate to the initial income per capita at the village level. The curve is the quadratic fit of the household initial income level and income growth. The horizontal axis is the initial income per capita while the vertical axis is the income growth rate.

To sum up, the whole discussion of this subsection delivers a message for the macro empirics focusing on inequality-growth nexus. Even if the specification of the growth function is correct, the aggregation effect still would cause errors that will be mistakenly taken into account as the impacts of income inequality on growth.

[16] Further discussions are provided in the Appendix B.

6 Conclusion

Is income inequality harmful to economic growth? This question has long been one of the core research questions among politicians, economists, and sociologists. Although majority existing empirical paper conclude that the impacts of income inequality on economic growth are negative, these studies might ignore the problems with aggregate data, namely, aggregate effects and the non-linearity of micro growth function. If these issues are not considered when using aggregate data, the adverse impacts of income inequality that have been found in previous empirical literature might be spurious. This paper intends to answer this question with micro data in hope of addressing with the potential concerns on macro data.

To confirm the concerns of macro data, the current study explores the effects of income inequality on economic growth at both micro (household) level and macro (village) level, with Chinses Household Income Project survey data. Similar to most of the existing literature, the estimation results with macro data show that the income inequality exerts adverse effect on economic growth. However, the estimation results obtained from micro data tell another story: the coefficients of income inequality are statistically significant. In addition, this positive effect will be impaired with the increase of initial household income level. Specifically, the households whose initial income per capita is greater than 9947 yuan will suffer from the adverse effects of income inequality, while the ones who live below this threshold will have a better income growth, keeping other factors unchanged. This result suggests that income inequality in rural China is an income growth driver for majority of the rural dwellers since the threshold (9947 yuan) is much higher than the mean of the household income per capita. In addition, combining the empirical evidence from both macro and micro regressions, they suggest that the political economy mechanism (as discussed as model 1 in Table 1) is predominant in rural China, and taxes and transfers are exactly the inappropriate policies, which has been discussed in (Ostry *el al.*, 2014).

Given two identical villages except for different degrees of income inequality, if you want to have a higher income growth, which village should you live in? Based on the empirical results from this paper, you will find that it is more depended on how much you earn at the moment. According to the economic convergence theory, although high initial income will lead to a relatively lower income growth, but it will be even slower in the village with higher income inequality. On the other hand, for the low initial household income, one's income growth will be accelerated in the village with higher income inequality. Instead, for policy makers, it is extremely important to notice the potential errors brought by the misspecification and aggregation effect. Ideally, combining both macro and micro empirical evidence will provide with a clearer picture of inequality-growth nexus.

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Appendix A. Robustness Checks with Different Measures on Inequality

Table A-1 Estimation Results for Model 11 – 14 with Mean-log-deviation

	Inequality Measure: Mean-log-deviation			
Independent Variables	(i)	(ii)	(iii)	(iv)
y_{t-1}	-10.255**	-0.948***	-2.485	-0.964***
	(4.106)	(0.165)	(2.200)	(0.192)
${y_{t-1}}^2$	0.026**	0.003***	0.045**	0.003***
	(0.011)	(0.001)	(0.019)	(0.001)
$Inequality_{t-1}^{v}$	2576**	-25.786	7799.61**	-31.334
	(1126.1)	(30.089)	(3452.751)	(44.502)
$y_{t-1} \times Inequality_{t-1}^{v}$	-	-	-66.900**	0.082
			(31.127)	(0.486)
$central$	-46.270	-8.659	-38.004	-8.639
	(104.278)	(7.135)	(102.053)	(7.146)
$west$	-140.430*	-20.182**	-109.862	-20.148**
	(75.244)	(8.700)	(69.098)	(8.715)
Constant	318.030**	69.935***	-447.321	70.885
	(145.204)	(9.295)	(289.948)	(10.867)
Data Level	Household	Village	Household	Village
Equation	4	5	7	6
R-square	0.013	0.099	0.028	0.099
N	5528	346	5528	346

Note: Standard errors are reported in brackets. *** Significant at 1 percent level. ** Significant at 5 percent level. * Significant at 10 percent level. Household (village) in Data Level row indicates the regression are examined with household (village) level data. The standard errors are corrected by clustering the village and are shown in the parentheses for the estimations at the household level. The dependent variable is growth rate of income. Growth rates are rescaled in percentage while the income per capita is rescaled in hundred.

Table A-2 Estimation Results for Model 11 – 14 (with Theil Index)

Independent Variables	Inequality Measure: Theil Index (i)	(ii)	(iii)	(iv)
y_{t-1}	-11.278**	-0.924***	-10.370**	-0.978***
	(4.490)	(0.166)	(4.078)	(0.180)
${y_{t-1}}^2$	0.031**	0.003***	0.037**	0.003***
	(0.013)	(0.001)	(0.015)	(0.001)
$Inequality_{t-1}^{v}$	286.073	-40.964	1494.092*	-72.433
	(215.098)	(30.949)	(872.399)	(50.599)
$y_{t-1} \times Inequality_{t-1}^{v}$	-	-	-13.525**	-0.322
			(7,906)	(0.410)
$central$	4.431	-8.473	-2.014	-8.209
	(105.003)	(7.111)	(105.041)	(7.123)
$west$	-182.679**	-19.952**	-177.276**	-19.733**
	(89.717)	(8.689)	(87.847)	(8.698)
Constant	701.270**	70.173	561.426**	74.469***
	(281.562)	(9.015)	(229.652)	(10.554)
Data Level	Household	Village	Household	Village
Equation	4	5	7	6
R-square	0.007	0.102	0.008	0.103
N	5528	346	5528	346

Note: Standard errors are reported in brackets. *** Significant at 1 percent level. ** Significant at 5 percent level. * Significant at 10 percent level. Household (village) in Data Level row indicates the regression are examined with household (village) level data. The standard errors are corrected by clustering the village and are shown in the parentheses for the estimations at the household level. The dependent variable is growth rate of income. Growth rates are rescaled in percentage while the income per capita is rescaled in hundred.

Appendix B. Deficiency in Data at Aggregate Level

This section shows the deficiency in macro data when aggregating from its micro raw data for certain variables. In this paper, the economic growth rate at the village level is computed as shown in the equation B.1, while the quadratic form of initial income level is calculated via equation B.2.

$$g^v = \frac{\Delta y^v}{y^v} = \frac{\Delta \bar{y}^h}{\bar{y}^h} = \frac{\sum_{i=1}^{H} \Delta y_i^h}{\sum_{i=1}^{H} y_i^h} = \frac{\sum_{i=1}^{H} (y_i^h \times g^h)}{\sum_{i=1}^{H} y_i^h} \neq \sum_{i=1}^{H} \frac{\Delta y_i^h}{y_i^h} \tag{B.1}$$

$$(y^v)^2 = (\bar{y}^h)^2 = \left(\frac{\sum_{i=1}^{H} y_i^h}{H}\right)^2 \neq \sum_{i=1}^{H} \frac{(y_i^h)^2}{H} \tag{B.2}$$

Where the superscript *v* denotes the variables are aggregated at the village level; *h* denotes the variables are the data at the household level; *H* is the number of households in the village; *g* is the economic growth and *y* is initial income level; operator Δ computes the change between *t* and *t-1*. The equation B.2 also requires the assumption that the number of household member is identical across households and do not change overtime.

Generally, the aggregated data should be the mean of its corresponding variables. One example is the initial income level of village, which could be obtained from the mean of the initial household income level. However, for the variables of economic growth and the quadratic term of village initial income level, as shown in B.1 and B.2, they are not purely the mean of their values at the household level, under the condition that the initial incomes of household are not identical across the village. This will bring errors to the estimation regression. These errors when aggregating data from household level, in the current research, are referred as aggregation effect, which is believed to be one of the factors that contributes to conflicting empirical results from micro and macro data. However, it is worth to note that the direction of the error is unclear.

Appendix C. Various Curvature of Household Income Growth Function

To illustrate that the impacts of income inequality are sensitive to the curvature of the household income growth function, this section will introduce three cases with various curvature regarding the household income function. As discussed in the paper, the fundamental settings of mathematical example also apply to the rest of discussion in this section. Suppose that in village *v*, there are only two households ($H = 2$) and each household has only one resident in every period ($n_1^h = n_2^h = 1$), therefore the total population (N^v) of village *v* is 2. The initial level of household income per capita for h_1 ($(y_1^h)_{-1}$) and h_2 ($(y_2^h)_{-1}$) are identical as Y. To monitor the impact of income inequality on economic growth, it is assumed that there is a mean-preserving income transfer from household h_1 to household h_2 by the non-zero amount of σ. After the income transfer, h_1 has $Y - \sigma$, while h_2 has $Y + \sigma$, enlarging the degree of income inequality ($Gini^v > 0$). It is worth noting that σ is standard deviation in this case, measuring the dispersion of household income per capita from the mean after the income transfer. The larger the σ, the more unequal in this village. At the village level, growth rate of income per capita (g^v), conventionally, can be computed as the growth rate of the mean income per capita of village *v*, which is shown as the equation C.1.

$$g^v = \frac{\Delta y^v}{y^v} = \frac{\Delta \bar{y}^h}{\bar{y}^h} = \frac{\sum_{i=1}^{H} \Delta y_i^h}{\sum_{i=1}^{H} y_i^h} = \frac{\sum_{i=1}^{H} (y_i^h \times g^h)}{\sum_{i=1}^{H} y_i^h} \qquad \text{(C.1)}$$

Case 1. A less curved case

If the household growth income function is given as the equation C.2, which does not allow any degree of curvature at all in the growth regression, the aggregate income growth at the village level should be expressed as the equation C.3. It is not merely the growth rate of the mean household income per capita $g^h(\bar{y}^h)$, but also includes an extra term $-\frac{\sigma^2}{Y}$. By taking the first order partial derivative with respect to σ to the village income growth (C.3), the result (C.4) suggests the sign of income inequality is negative. It implies that the impact of income inequality is negatively associated to the aggregate income growth, which is consistent to majority of traditional empirical literature.

$$g^h(y^h) = \alpha_0 - y^h \tag{C.2}$$

$$g^v = \frac{\sum_{i=1}^{H}(y_i^h \times g^h)}{\sum_{i=1}^{H} y_i^h}$$

$$= \frac{[\alpha_0 - (Y - \sigma)](Y - \sigma) + [\alpha_0 - (Y + \sigma)](Y + \sigma)}{Y - \sigma + Y + \sigma} \tag{C.3}$$

$$= \frac{\alpha_0 Y - Y^2 - \sigma^2}{Y} = g^h(\bar{y}^h) - \frac{\sigma^2}{Y}$$

$$\frac{\partial g^v}{\partial \sigma} = -\frac{\sigma^2}{Y} < 0 \tag{C.4}$$

Case 2 A threshold case

If certain curvature is allowed to be considered in the household income growth function, such as the equation C.5, through the similar analysis to the case 1 (C.6), village income growth equal to the growth rate of mean household income. By computing the partial effects of income inequality (C.7), it can be concluded that income inequality has no impact on village income growth, if the household growth function is specified as equation C.5.

$$g^h(y^h) = \frac{\alpha_0}{y^h} \tag{C.5}$$

$$g^v = \frac{\sum_{i=1}^{H}(y_i^h \times g^h)}{\sum_{i=1}^{H} y_i^h}$$

$$= \frac{\frac{\alpha_0}{Y - \sigma} * (Y - \sigma) + \frac{\alpha_0}{Y + \sigma} * (Y + \sigma)}{Y - \sigma + Y + \sigma} \tag{C.6}$$

$$= g^h(\bar{y}^h) = \frac{\alpha_0}{Y}$$

$$\frac{\partial g^v}{\partial \sigma} = 0 \tag{C.7}$$

Case 3 A more curved case

If the household growth function is given as equation C.8, then the income growth at the village level can be expressed as C.9. By taking the first order condition with respect to σ, the result in C.10 shows that income inequality is positively associated to the village income growth.

$$g^h(y^h) = \frac{\alpha_0}{(y^h)^2} \tag{C.8}$$

$$g^v = \frac{\sum_{i=1}^{H}(y_i^h \times g^h)}{\sum_{i=1}^{H} y_i^h} = \frac{\frac{\alpha_0}{Y-\sigma} + \frac{\alpha_0}{Y+\sigma}}{Y-\sigma+Y+\sigma} = \frac{\alpha_0}{Y^2-\sigma^2} \tag{C.9}$$

$$\frac{\partial g^v}{\partial \sigma} = \frac{2\sigma\alpha_0}{(Y^2-\sigma^2)^2} > 0 \tag{C.10}$$

Table C-1 summarizes the results for all three cases with different assumptions on the household income growth function. It clearly shows that the change of income growth rate at the village level is sensitive to the curvature of household income growth function. Particularly, when the household income growth is inverse to the initial household income per capita, the change in income inequality has no effects on the village economic growth at all (case 2). If the household income growth function is less curved as specified in case 1 (more curved as specified in case 3), then an increase in income inequality will lead to a decrease (increase) in village economic growth.

Table C-1. Summary of All Cases with Various Curvature on Growth Function

Case	Household Growth Function	Curvature	$\frac{\partial g^v}{\partial \sigma}$	Results
1	$\alpha_0 - y^h$	less curved	$-\frac{\sigma^2}{Y} < 0$	Decreased
2	$\frac{\alpha_0}{y^h}$	threshold	0	unchanged
3	$\frac{\alpha_0}{(y^h)^2}$	more curved	$\frac{2\sigma\alpha_0}{(Y^2-\sigma^2)^2} > 0$	Increased