Growth and income inequality

Menglin Shao

Department of Economics
University of Waterloo
Waterloo, Ontario, Canad

Econ 472 section 1

Senior Honours Essay

Course instructor: Trien T. Nguyen

Essay supervisor: Pierre Chaussé

April 11,2019

Abstract

The objective of this paper is to test the hypothesis of conditional convergence among Chinese provinces, evaluate the relationship between income inequality and economic growth, and analyze whether the convergence is related to income inequality. We propose to analyze the effect of income inequality using the Gini coefficient. The analysis covers thirty-one Chinese provinces from 1997 to 2017 and is based on the estimation of panel growth equations using OLS, WG and DIF-GMM estimators. Three main results can be drawn from our empirical investigations. Firstly, conditional convergence exists among Chinese provinces and controlling other similar characteristics, poorer provinces growth faster than the richer ones. Secondly, the estimator of the Gini coefficients does not show a significant relationship between income inequality and growth. It can only suggest that higher inequality seems to lower growth. Thirdly, in stable income inequality or increasing trends of inequality, we do not see the evidence of convergence; while, in a period of declining income inequality, we can detect a significant absolute convergence result. Further study is needed to test the causality between convergence and trending of income inequality.

Acknowledgments

I would like to offer my sincerest gratitude to my course instructor Prof. Trien T. Nguyen and my essay supervisor Prof. Pierre Chaussé. Without their unconditional support and insightful feedback, none of this would have been possible. Words cannot express how appreciative I am for everything they have done. I am deeply thankful to have learned a tremendous amount from them.

Table of Contents

1. Introduction

The objective of this paper is to test the hypothesis of conditional convergence among Chinese provinces, evaluate the relationship between income inequality and economic growth, and analyze whether the convergence is related to the income inequality.

Inequality affects everyone, and it may impede the pace of economic growth. Economists are focusing on the links between rising inequality and sustainable growth. Many studies have concentrated on the inequality is harmful to the pace and sustainability of economic growth on a world-wide perspective. However, very few of them has looked at the problem within one country. By analyzing convergence inside one country, it is easier to control for things difficult to observed homogeneously, for example, policy, political system, and cultural diversity, etc.), which could be the source of consistency estimator. Therefore, in this paper, we apply this within one country estimation method to analyze the relationship between income inequality and growth in GDP among Chinese provinces. Moreover, the conditional convergence hypothesis in China is also tested. Leading by the pioneering work of Solow, many empirical studies have focused on the conditional convergence of GDP per capita. This hypothesis implies that controlling for differences in other potential aspects, poor economies will grow faster than richer ones. In addition, this paper also analyzes whether the process of convergence is related to the income inequality.

In order to explore the relationship between inequality and growth, we propose to analyze the effect of inequality using the Gini coefficient.[1] Because of the 'sweep away' problem for the time-

[1] Gini coefficient is a widely used measure of income inequality. It is a measure of statistical dispersion intended to represent the income or wealth distribution of a nation's residents, which ranges from 0 (perfect equality) to 1 (perfect inequality). A higher value of the Gini coefficient suggests a higher inequality of income distribution.

invariant Gini coefficient, the two-stage process is employed to estimate economic growth models. We proposed to use the most recent techniques of dynamic panel data models. In the first-stage, to test the hypothesis of conditional convergence across Chinese provinces, three kinds of generalized method of moments (GMM) models are applied to obtain results: Ordinary Least Squares (OLS), Within Groups estimation (WG), and First difference Generalized method of moments (DIF-GMM). Next, in the second-stage, we used the results in the first-stage to investigate the relationship between income inequality and economic growth. The fixed effects model with time-invariant regressors is used since these variables are "swept away" in first-stage by the within estimator on the time-varying covariates (Ronald L. Oaxaca, 2003). The econometric analysis involves thirty-one Chinese provinces from 1997 to 2017 using the data from China Family Panel Studies (CFPS) and the National Bureau of Studies of China (NBS), and the OECD National Accounts database (2012).

To summarize our results as follows, firstly, conditional convergence exists among Chinese provinces, which means that poorer provinces growth faster than the richer ones. Secondly, the regression results seem a non-significant relationship between income inequality and growth. The coefficients only suggest that higher inequality seems to lower growth. Thirdly, we do find a relationship from 1991 up to now on high convergence accompany of low inequality.

The remainder of this paper is organized as follows. Section 2 reviews the literature on conditional convergence of GDP and income inequality in China. This section also discusses the conceptual framework of convergence and the selection of its determinants are described. Then, Section 3 demonstrates the methodology of panel growth models, and its estimation methods: OLS, WG, and DIF-GMM; as well as the fixed effects models with time-invariant regressors. Section 4 introduces the data. Section 5 presents the estimation results under the GMM models mentioned above and prove the hypothesis test for conditional convergence. In section 6, we investigate whether the fluctuations in income inequality has been accompanied by a process of convergence, and we conclude in section 7.

2. Literature review

2.1 Income inequality in China

Since the economic reformation of 1978, China's economic development has experienced remarkable achievements (Fan 2006). This first stage of economic reforms led by Deng Xiaoping's policy is to let some people get rich first. However, from the 1990s, this unbalanced policy designed to accelerate economic growth has exacerbated economic inequality in China, with urban cities becoming richer and more prosperous, while the rural areas remaining underdeveloped (Naughton, 2002). Moreover, the Gini coefficient of GDP per capita has shown an upward trend since 1990, which demonstrates increasingly continuous disparity in China's (Zhao and Tong, 2000; Zheng et al., 2000; Démurger, 2001; Cai et al., 2002; Lu and Wang, 2002; Kanbur and Zhang, 2005). The long-standing and excessively large economic inequality not only cause imbalances in income distribution and welfare losses but is also likely to affect the overall efficiency of the economy and social stability (Berg, 2018). Nevertheless, some recent studies (Li and Xu, 2008; Villaverde et al., 2010; Hao and Wei, 2010) notice that the increase in income inequality started to decline in 2000. Besides, the survey from OECD (2010) also suggests that household income inequality seems to have a decreasing tendency during last decade. The decreasing disparity may lead to some encouraging results for Chinese economy, including faster and more stable growth, etc. Regarding the convergence of Chinese economy, most of the existing literatures shows that there is convergence of GDP in China.

Moreover, we also intend to investigate whether the decreasing in income inequality is accompanied with faster growth. The question of convergence across Chinese provinces since the reform era has been addressed in many empirical papers. A comparative analysis of the findings of these studies suggests that there is little consensus (Li and Xu, 2008). Some authors validate the hypothesis of conditional convergence (Chen and Fleisher, 1996; Cai et al., 2002), while others give evidence of provincial divergence (Pedroni and Yao, 2006).

2.2 Conceptual framework

2.2.1 Growth convergence

Leading by the neoclassical growth model pioneered by Solow (I956), empirical economists have focused on the convergence hypothesis. Two concepts of convergence have been proposed to analyze the law of growth in these discussions (Barro and Sala-i-Martin,1992). The first one is absolute convergence. It stands for the hypothesis that poor economies will grow faster than richer ones and eventually catch up with the riches. In other words, economies tend to converge into one steady-state. The other one is conditional convergence. It recognizes differences between economies and assumes that the further it is from its steady-state, the faster it grows. Therefore, we only see convergence of GDP among provinces with similar characteristics.

Most of the existing macroeconomic models generally predict that economic growth in each region should be converging (e.g., Solow, 1956), and this prediction has been multifaceted in the empirical analysis, exemplified by Barro (1991) and Mankiw et al. (1992). They have shown evidence that by controlling for the population growth rates and saving rates, economies with low initial incomes tend to grow faster than those with high initial incomes. This finding has generally been considered as a pivotal affirmation that the neoclassical growth model (Solow, 1956) is consistent with empirically observed growth patterns. Moreover, Sala-i-Martin (1992) defined the cross-section regression approach which is popular in empirical econometrics analysis work. In particular, he formalized an approach to test the hypothesis of conditional convergence that is testing the negative coefficient on initial income (per capita GDP) in a cross-section regression of growth rate controlling for other covariates.

2.2.2 Growth model and convergence hypothesis

Following Durlauf et al. (2005) and Caselli et al. (1996), the growth equation we choose to estimate:

$$lnY_{i,t} - lnY_{i,t-\tau} = \widetilde{\gamma_1} lnY_{i,t-\tau} + \gamma_2 Z_{i,t-\tau} + \beta Gini_i + u_i + \varepsilon_{i,t} \,. \qquad (1)$$

Where $Y_{i,t}$ is per capita GDP in province i, period t; $Z_{i,t}$ stands for additional determinants from endogenous growth models (Romer, 1986; Barro, 1991), and other traditional determinants of growth in accordance with models of conditional convergence (Solow, 1956; Mankiw et al., 1992); $Gini_i$ is the Gini-coefficient for province i; u_i is a province-specific operator; and $\varepsilon_{i,t}$ is an overall error term.

Equation (1) can be rewritten as a dynamic panel equation with the lagged dependent variable on the right-hand-side with $\gamma_1 = \widetilde{\gamma_1} + 1$, and $y_{i,t} = lnY_{i,t}$. The panel growth model is:

$$y_{i,t} = \gamma_0 + \gamma_1 y_{i,t-\tau} + {\gamma_2}^T Z_{i,t-\tau} + \beta Gini_i + u_i + \varepsilon_{i,t} \; . \qquad (2)$$

In Solow growth model, the initial level of income is considered as a strong determinant of differences in growth rates across countries. The hypothesis test of conditional convergence is to test whether the poorer provinces grow at a higher speed than the richer provinces, holding all other variables equal. As a result, under the hypothesis, the associated coefficient of initial per capita GDP--$\widetilde{\gamma_1} = \gamma_1 - 1$ is expected to be significant and negative (Solow, 1956; Barro and Sala-i-Martin, 1995).

2.2.3 Determinants of growth model

The panel economic growth model used in this paper consists of the past-per capita GDP ($y_{i,t-\tau}$), and some other time-varying independent variables in

$$Z_{i,t} = (N_{i,t}, I_{i,t}, T_{i,t}) \; , \quad (3)$$

including the natural growth rate ($N_{i,t-\tau}$), which is the sum of population growth rate plus a common exogenous rate of technical change and a depreciation rate. Other than that, the total investment ($I_{i,t-\tau}$), international trading volume ($T_{i,t-\tau}$), as well as the provincial time-fixed effect—Gini coefficient ($Gini_i$) are also contained in this model.

Natural growth rate

Empirical studies emphasize the influence of natural growth rate. Some theoretical analyses argue that a rise in fertility rate (stands for the natural growth rate) may create pressures on limited natural resources and may be identified as an opportunity cost of productive activities. The underlying point is that if the population increases, new workers will have an increasing demand that causes a reduction in private and public capital formation (Barro, 1998). As a consequence, the natural growth rate is assumed to have a negative effect on economic growth.

Physical investment

Physical capital accumulation is also an important determinant of growth in both Solow's neoclassical growth models, since it is a component of aggregate demand. More importantly, it guides the productivity of the economy. It implements the multiplier effect. The initial investments are acquired by firms to implement production, and then, if firms gain satisfied profit and returns, they are more likely to reinvest this in further investment. In this way, this reinvestment will then further extend the productive capacity of the economy. Eventually, these investments can produce growing returns and promote economic growth. Hence, the investment is supposed to have a positive effect on growth progress.

Imports and Exports Performance

Economists had an optimistic view of the relationship between foreign trade and economic growth (Ali, 2017). Imports allow global competition to reduce prices and gives a wider variety of choices for consumers. Exports create job opportunities and boost speciallization in manufacture. Therefore, trade also makes production more efficient. Accordingly, these positive effects have led to the creation of a new international trading system that aims to liberalize global trade of all tariff and non-tariff barriers and open markets to exports from all countries. This trade internationalization further promotes economic growth. Thus, the impact of imports and exports on economic growth is positive.

Income inequality

The answer to the debate of how uneven household income affects a country's growth is still not clear. Thus, an increasing number of articles have studied the relationship or causality between rising inequality and sustainable growth rate. Some literature emphasized that inequality can promote growth by fostering incentives for innovation and entrepreneurship (Lazear and Rosen, 1981) and raising saving and investment if rich people save a higher fraction of their income (Kaldor, 1957). While others suggest that inequality is one of the crucial aspects that impede the pace of economic growth. These empirical literatures seem to have focused on a tentative consensus that inequality is generally harmful to the pace and sustainability of economic growth from a world-wide perspective. Galor and Zeira (1993) emphasized the interaction of credit market imperfections and fixed costs of investment in physical and human capital markets, showing that inequality can lead to under-investment in human capital and reduced growth. Galor and Moav (2004) argued that the higher the relative return to physical capital, higher the impact of inequality on growth. Along related lines, de la Croix and Doepke (2003) noticed that inequality rises the proportion of the poor and hence reduces human capital accumulation and decelerates economic growth. Berg (2018) concluded that lower net inequality is strongly and robustly correlated with faster and more durable growth, controlling other determinants. However, a comparative analysis within one country is not well-developed. To address these concerns, this paper proposes to analyze the effect of inequality using the Gini coefficient among province.

3. Methodology

The Gini coefficient is a provincial effect. In addition, this time-invariant explanatory variable is correlated with other covariates in the model. In a panel growth model, when evaluating the coefficients on the time-varying covariates, this time-invariant variable is ‘‘cancelled out’’ by the within estimation. Thus, it is essential to consistently estimate the effects of this time-invariant covariate through two-stage procedures. In the first stage, OLS, WG and DIF-GMM are applied to estimate the coefficients using a model with provincial fixed-effect. According to Bond et al. (2001), OLS is simple, easier to get some consistent, in general, unbiased estimator without solving the endogenous problem. On top of that, it tends to overestimate in the presence of the correlation between explanatory variables. While WG is more likely to provide consistency because the unobserved endogeneity across provinces, but tends to underestimate in short panels, especially with omitted variables. As a solution to OLS and WG, DIF-GMM is more likely to be consistent since it simultaneously addresses both omitted variable bias and endogeneity issues. We will compare the results for these three methods. Next, in the second stage, we measure the estimator β for relationship between growth and inequality using OLS approach (Oaxaca and Geisler, 2003).

3.1 First-stage estimation

In the first-stage, the simplified growth model to be estimated is:

$$y_{i,t} = \alpha X_{i,t-\tau} + \eta_i + \varepsilon_{i,t}\ , \qquad (4)$$

where $X_{i,t-\tau} = (y_{i,t-\tau},\ N_{i,t-\tau},\ I_{i,t-\tau},\ T_{i,t-\tau})^T$ is a vector of observations consisting all the time-varying covariates; η_i is a provincial fixed effect; and $\alpha = (\gamma_1, \gamma_2, \gamma_3, \gamma_4)^T$ is the parameter vector.

Consider the restriction:

$$\eta_i = \gamma_0 + \beta Gini_i \ , \qquad (5)$$

where γ_0 is a constant, $Gini_i$ is a vector of time invariant covariates, β is the coefficient for the Gini coefficients.

3.1.1 OLS

By simply detach the time-invariant covariate, the basic fixed-effect model to be estimated using OLS is:

$$y_{i,t} = \alpha X_{i,t-\tau} + \varepsilon_{i,t} \ . \qquad (6)$$

We can directly solve Eq. (6) to get the OLS estimator:

$$\hat{\alpha}^{OLS} = (X^T X)^{-1} X^T y \ . \qquad (7)$$

3.1.2 WG

When considering the simplified panel regression Eq. (4) with a single regressor, the goal for Within Group estimation is to remove the fixed-effect η_i. We firstly take the group average of every variables for each i over time t:

$$\bar{y}_i = \alpha \bar{X}_i + \eta_i + \bar{\varepsilon}_i \ , \quad (8)$$

where $\bar{y}_i = \frac{1}{T}\sum_{t=1}^{T} y_{i,t}$, $\bar{X}_i = \frac{1}{T}\sum_{t=1}^{T} X_{i,t}$, $\bar{\varepsilon}_i = \frac{1}{T}\sum_{t=1}^{T} \varepsilon_{i,t}$, and so does $\eta_i = \frac{1}{T}\sum_{t=1}^{T} \eta_i$.

Secondly, the transformed regression is rewritten using the group mean average,

$$y_{i,t} - \bar{y}_i = \alpha\big(X_{i,t-\tau} - \bar{X}_i\big) + (\eta_i - \eta_i) + (\varepsilon_{i,t} - \bar{\varepsilon}_i) \ . \quad (9)$$

In this case, the fixed-effects within estimator can be used to estimate α from the model:

$$\tilde{y}_{i,t} = \alpha \tilde{X}_{i,t-\tau} + \tilde{\varepsilon}_{\ i,t} \ . \quad (10)$$

Thus, the WG fixed-effect estimator on the transformed regression (stacked by observation) is

$$\hat{\alpha}^{WG} = (\tilde{X}^T \tilde{X})^{-1} \tilde{X}^T \tilde{y} \ . \quad (11)$$

3.1.3 DIF-GMM

The above two estimation methods of panel growth model may raise a variety of problems. It is known that OLS overestimate in the presence of the correlation between the lagged value of the dependent variables and the individual-specific effects (Hsiao, 1986). Also, the WG underestimate in short panels, especially with omitted variables (Nickell, 1981). Thus, a consistent estimate of these first stage time-varying covariates can be obtained by removing the cross-sectional variation. One such estimator is the first-difference GMM (DIF-GMM) estimator which involves taking the first difference of the levels Eq. (4) thus eliminating the individual effect η_i (Arellano and Bond, 1991). The DIF-GMM is a typical solution that researchers used where the potentially endogenous explanatory variables are instrumented using appropriate lagged values and rational differences.

We first set out the first-difference GMM approach to eliminate the individual specific effects η_i.

$$y_{i,t} - y_{i,t-\tau} = \alpha(X_{i,t-\tau} - X_{i,t-2\tau}) + (\eta_i - \eta_i) + (\varepsilon_{i,t} - \varepsilon_{i,t-\tau}) . \qquad (12)$$

By substituting $\Delta y_{i,t} = y_{i,t} - y_{i,t-\tau}$, $\Delta X_{i,t-\tau} = X_{i,t-\tau} - X_{i,t-2\tau}$, and $\Delta\varepsilon_{i,t} = (\varepsilon_{i,t} - \varepsilon_{i,t-\tau})$, we can rewrite Eq. (12) such that

$$\Delta y_{i,t} = \alpha\Delta X_{i,t-\tau} + \Delta\varepsilon_{i,t} . \qquad (13)$$

Eq. (6) shows that $\Delta X_{i,t}$ is correlated with the differential error term $\Delta\varepsilon_{i,t}$. In consequence, it is necessary to rely on instrumental variables techniques. Considering Eq. (4), and let $\eta_i + \varepsilon_{i,t} = \upsilon_{i,t}$,

$$E[\eta_i] = 0, E\left[\varepsilon_{i,t}\right] = 0, E\left[\eta_i\varepsilon_{i,t}\right] = 0 \; for \; i = 1, \dots, N \; and \; t = \tau, \dots, T.$$

We assume that the transient errors are serially uncorrelated

$$E\left[\varepsilon_{i,t}\varepsilon_{i,s}\right] = 0, for \; t \neq s \; and \; i = 1, \dots, N ,$$

and that the initial conditions $X_{i,1}$ are predetermined

$$E\left[X_{i,1}\varepsilon_{i,t}\right] = 0, for \; i = 1, \dots, N \; and \; t = \tau, \dots, T ,$$

which implies the following moment restrictions:

$$E\left[X_{i,t-\tau}\Delta\varepsilon_{i,t}\right] = 0, for\ i = 1, \dots, N\ and\ t = \tau, \dots, T\ .$$

These are the moment restrictions exploited by the standard linear first-differenced GMM estimator, implying the use of lagged levels dated $t-\tau$ and earlier as instruments for the equations in first-differences (Arellano and Bond, 1991). This yields a consistent estimator of α as N→∞ with fixed T. Hence, we can construct an instrument matrix using the lagged levels dated $t-\tau$ and earlier as instruments for the Eq. (13) in first-differences.

$$E[S_i^T \Delta\varepsilon_i] = 0\ , \quad (14)$$

where the instrument matrix S_i is:

$$S_i = \begin{bmatrix} X_{i,1} & 0 & 0 & \dots & 0 & \dots & 0 \\ 0 & X_{i,1} & X_{i,2} & \dots & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & X_{i,1} & \dots & X_{i,T-\tau} \end{bmatrix}, \quad (15)$$

and $\Delta\varepsilon_i = (\Delta\varepsilon_{i,\tau}, \Delta\varepsilon_{i,\tau+1}, \dots, \Delta\varepsilon_{i,T})^T$.

3.2 Second-stage estimation

To deal with the ‘swept away’ problem of time-invariant variable in the first stage, we use a two-stage estimation procedure for consistent estimation of the coefficients on the time invariant regressors.

Denote the estimator of the time-varying covariates in the first stage as $\hat{\alpha}$. Upon subtracting $\bar{X}_i\hat{\alpha}$ from both sides of Eq. (4) we obtain:

$$\bar{y}_i - \bar{X}_i\hat{\alpha} = \eta_i + \sigma_{i,t} + \bar{X}_i(\alpha - \hat{\alpha})$$

$$= \gamma_0 + \beta Gini_i + \sigma_{i,t} + \bar{X}_i(\alpha - \hat{\alpha})$$

$$= K_i\theta + v_i \quad , \qquad (16)$$

where $v_i = \sigma_{i,t} + \bar{X}_i(\alpha - \hat{\alpha})$, K_i=$(1, Gini_i)$, and θ=$(\gamma_0, \beta)^T$. Thus, our two-stage estimator of

$\hat{\theta}^{2SE} = (K^TK)^{-1}K^T(\bar{y} - \bar{X}\hat{\alpha})$.

4. Empirical data

The analysis covers thirty-one Chinese provinces over 1997-2017 using the data from the National Bureau of Studies of China (NBS). It provides all the time-varying explanatory variables that correspond to the different determinants of our growth panel model in section 2.3. Firstly, the past-per capita is proxied by the gross regional product of each province. Secondly, the impact of natural growth rate is approximately equal to the population growth rate plus 0.05. Specifically, from past literature (Mankiw et al. 1992), researchers assume 0.05 use the sum of the rate of technical progress and the rate of depreciation of physical capital. Thirdly, the total investment in fixed assets is included to approximate for physical investment. Fourthly, we also take the total amount of import and export into account for the international trading performance.

While there are plenty of studies (Xie and Zhou, 2014) estimating the Gini coefficient at the national level, Gini coefficient estimates for each of the Chinese provinces are scarcer. Moreover, the Gini coefficients for each province are not officially posted online. In this case, this paper use two methods to obtain the provincial Gini coefficients. The first way is to calculate by the survey data from China Family Panel Studies (CFPS) conducted by the Institute of Social Science Survey at Peking University. This dataset contains thirty-one provinces of China (excluding Taiwan, Hong Kong, and Macau) from 2000-2017 representing about 16,000 households in mainland China. Applying the multistage probability sampling procedure, this study conducted interviews with these sampled households and all individuals living in it. To calculate each province's Gini coefficient, we focus on the 2016 baseline survey of the CFPS, which is the largest scale among all the survey. A list of questions is asked for each family to collect information on labor income, business income, investment income, transfer income, and income from other sources, from which we constructed total family income as our variable of interest. Using these survey data to calculate the provincial Gini coefficient, the result shows that there is not a significant difference among each province. Table. 1 represents the estimated Gini coefficients for each province using the data from CFPS.

The second way is to directly use the estimated provincial Gini coefficient in Bhattacharya at el.'s paper. They use the error function method to calculate the estimated Gini coefficients for each of the 31 provinces and these results are presented in Table 2. Their outcome demonstrates remarkable diversify among provinces and thus can be used to in the following panel regression model.

Table 1. Estimation of provincial Gini coefficient using CFPS

Province	Gini coefficient	Province	Gini coefficient
Beijing	0.493	Hubei	0.501
Tianjin	0.542	Hunan	0.482
Hebei	0.474	Guangdong	0.540
Shanxi	0.699	Guangxi	0.571
Inner Mongolia	0.403	Hainan	0.247
Liaoning	0.533	Chongqing	0.453
Jilin	0.47	Sichuan	0.518
Heilongjiang	0.437	Guizhou	0.674
Shanghai	0.555	Yunnan	0.522
Jiangsu	0.535	Tibet	0.014
Zhejiang	0.439	Shaanxi	0.513
Anhui	0.56	Gansu	0.474
Fujian	0.663	Qinghai	0.207
Jiangxi	0.405	Ningxia	0.327
Shandong	0.502	Xinjiang	0.346
Henan	0.45		

Using the summation of five kinds of income (family wage + operate + transfer(subsidy) + property + else income) in CFPS

Table 2. Estimation of provincial Gini coefficient by Bhattacharya at el.

Province	Gini coefficient	Province	Gini coefficient
Beijing	0.97	Hubei	0.06
Tianjin	0.85	Hunan	0.06
Hebei	0.79	Guangdong	0.99
Shanxi	0.71	Guangxi	0.06
Inner Mongolia	0.26	Hainan	0.65
Liaoning	0.2	Chongqing	0.06
Jilin	0.06	Sichuan	0.06
Heilongjiang	0.06	Guizhou	0.06
Shanghai	0.98	Yunnan	0.9
Jiangsu	0.92	Tibet	0.59
Zhejiang	0.97	Shaanxi	0.06
Anhui	0.06	Gansu	0.06
Fujian	0.84	Qinghai	0.56
Jiangxi	0.84	Ningxia	0.68
Shandong	0.83	Xinjiang	0.93
Henan	0.06		

Estimates of provincial Gini coefficients 2000-2012 (Bhattacharya and Palacio-Torralba, 2018)

5. Estimation results

In this section, we considering the results of applying the two-stage estimation for the panel growth model mentioned in section 3. We use the dataset specified in section 4 and take the log-transformation of all time-varying covariates. Following earlier studies in the literature, we rely on two-year non-overlapping time intervals (i.e. τ = 2). In this case, we have twenty-two years and divide the data into seven periods. We can rewrite Eq. (3) as follow:

$$y_{i,t} = \gamma_0 + \gamma_1 y_{i,t-2} + {\gamma_2}^T \ln(Z_{i,t-2}) + \beta Gini_i + \varepsilon_{i,t}\ . \qquad (17)$$

5.1 First-stage estimation

The first three columns of Table 3 report the results in the first-stage using OLS, WG and DIF-GMM estimators respectively. To isolate causal effects, DIF-GMM relies on a set of internal instruments, consisting of various lagged levels and differences of right-hand-side time-varying variables. Eight instruments used for DIF-GMM (column (iii)) are $y_{i,t-2}$, $\ln(N_{i,t-2})$, $\ln(I_{i,t-2})$, $\ln(T_{i,t-2})$, and further lags, $y_{i,t-3}$, $\ln(N_{i,t-3})$, $\ln(I_{i,t-3})$, $\ln(T_{i,t-3})$.

In all the three models, the estimated coefficient associated to the initial level of per capita GDP is negative and significant (at least at the 5% level). This negative correlation indicates that among provinces that share the same economics structural characteristics, those which were initially richer have slower growth rate over the period, whereas the growth rate of poorer provinces has been higher. In other words, this result means that each province is converging toward its own steady-state level when we control for the other set of variables, the hypothesis of conditional convergence is validated during the period 2000-2017 in China. Therefore, we may see convergence of GDP among provinces with similar characteristics.

Moreover, the estimator of other invariant determinants also indicates interesting conclusions. Firstly, these three methods all suggest that the natural growth rate has a detrimental effect on economic growth since the coefficient associated with it is negative and significant at the 5% level. This consequence means that provinces with a higher population growth rate tend to record a significantly lower growth of their GDP per capita. This result may be explained by Solow's concept (1956, p. 90), which supposes that a slower population growth results in a higher equilibrium level of both the output and capital stock per worker. Secondly, all the significantly positive coefficients on total investment value respectively at the 1% and 5% level underline that the accumulation of physical capital can, therefore, be considered as an engine of regional growth over the period 2000-2017. Last but not least, in each of the three models, the total amount of international trading also has an accelerated contribution to economic growth. It means that provinces that generate better export productions and contain more import consumption tend to record higher growth rate of their GDP per capita. All in all, these significant estimated results of coefficients suggest that the natural growth rate, the overall physical investment, and the total trading volume are key factors that affect the regional economic growth. In addition, their participation also promotes the reduction of regional

In all the three models, the estimated coefficient associated to the initial level of per capita GDP is negative and significant (at least at the 5% level). This negative correlation indicates that among provinces that share the same economics structural characteristics, those which were initially richer have slower growth rate over the period, whereas the growth rate of poorer provinces has been higher. In other words, this result means that each province is converging toward its own

Table 3. First-stage estimation of the panel growth model

Model	OLS	WG	DIF-GMM
(intercept)	**0.385749*** **	---	---
	(0.046067)	---	---
$y_{i,t-2}$	**-0.146481*** **	**-0.3184844*** **	**-0.4519880*** **
	(0.016114)	(0.0270769)	(0.0887641)
$\ln(N_{i,t-2})$	**-0.004253** **	**-0.0052402* **	-0.0058713
	(0.001599)	(0.0022356)	(0.0061625)
$\ln(I_{i,t-2})$	**0.067579*** **	**0.1351769*** **	**0.1710053*** **
	(0.011788)	(0.0098999)	(0.0370101)
$\ln(T_{i,t-2})$	**0.036031*** **	**0.0257933*** **	**-0.0536755 .**
	(0.004846)	(0.0075787)	(0.0320689)
Overall p-value	< 2.2e-16	< 2.22e-16	4.2311e-08

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: Author's calculation, based on NBS (1997-2017).

steady-state level when we control for the other set of variables, the hypothesis of conditional convergence is validated during the period 2000-2017 in China. Therefore, we may see convergence of GDP among provinces with similar characteristics.

Moreover, the estimator of other invariant determinants also indicates interesting conclusions. Firstly, these OLS and WG suggest that the natural growth rate has a detrimental effect on economic growth since the coefficient associated with it is negative and significant at the 5% level, while DIF-GMM indicates an insignificant result. This consequence means that provinces with a higher population growth rate tend to record a significantly lower growth of their GDP per capita. This result may be explained by Solow's concept (1956, p. 90), which supposes that a slower population growth results in a higher equilibrium level of both the output and capital stock per worker. Secondly, all the significantly positive coefficients on total investment value at a less than 1% level underline that the accumulation of physical capital can, therefore, be considered as an engine of regional growth over the period 1997-2017. Last but not least, in each of the three models, the total amount of international trading also has an accelerated contribution to economic growth. It means that provinces that generate better export productions and contain more import consumption tend to record higher growth rate of their GDP per capita. All in all, these estimated results of coefficients suggest that the natural growth rate, the overall physical investment, and the total trading volume are key factors that affect the regional economic growth.

5.2 Second-stage estimation

After estimating the model, we simply use OLS to conduct the second-stage to estimate the relationship between inequality and economic growth. We compare the estimation results using the provincial Gini coefficients in Bhattacharya at el.'s paper as well as the one directly calculated from CFPS dataset. The result is respectively shown in Table 4 and Table 5 below.

The regression results do not show a significant relationship between income inequality and growth. The coefficients only suggest that higher inequality seems to lower growth. This result may because of the inaccurate outcomes of briefly measured Gini coefficients we used. For further estimation, we may need more accurate and comprehensive data which can clearly demonstrate the income distribution among every household. Specifically, we may see

$$\eta_i = \gamma_0 + \beta Gini_i + other\ provincial\ specific\ covariates\ . \quad (18)$$

Then, the identification of the effect of Gini coefficients can be improved.

6. Income inequality vs. convergence

In this section, we want to investigate whether the fluctuations in income inequality has been accompanied by a process of convergence. We intend to contribute to this debate by estimating economic panel growth models using the lagged levels dated $t-1$. The dynamics panel model for testing the convergence hypothesis is shown below:

$$lnY_{i,t} - lnY_{i,t-1} = \lambda\ lnY_{i,t-1} + \varepsilon_{i,t}\ . \quad (19)$$

The coefficient associated with the convergence λ has been estimated through three different periods. The first period is from 1959 to 1977 when China was implementing Planned economy and still remaining as part of the Third World. At that time, Chinese households were almost of equal income level. The second period is from 1978 to 1990. During this time-interval, China was experiencing the economic reformation that has accelerated economic growth, while on the other hand, exacerbated income inequality. The last period is from 1991 up to now. During this period,

Table 4. Second-stage estimation of the panel growth model using Gini coefficients in Bhattacharya at el.'s paper

Second-stage Model	OLS	Within-groups	DIF-GMM
(intercept)	0.01372	-0.008997	**0.276125*** **
	(0.01224)	(0.011883)	(0.009663)
$Gini_i$	-0.02801	-0.018374	-0.017153
	(0.01968)	(0.019106)	(0.015609)
Overall p-value	0.1652	0.3442	0.2823

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: Author's calculation, based on NBS (1997-2017).

Table 5. Second-stage estimation of the panel growth model using Gini coefficients from CFPS

Second-stage Model	OLS	Within-groups	DIF-GMM
(intercept)	**-0.07518****	0.00443	**0.27644*****
	(0.02515)	(0.02767)	(0.02527)
$Gini_i$	-0.06070	-0.00947	-0.01754
	(0.05179)	(0.0569)	(0.05028)
Overall p-value	0.1652	0.3442	0.2721

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: Author's calculation, based on NBS (1997-2017) and CFPS (2000-2017).

inequality is decreasing as the economy is growing fast. The estimation results are demonstrated in Table 6 below:

In the first and second periods, the coefficients for $lnY_{i,t-1}$ are positive which means there is no evidence of convergence during these two periods. While during the third period, the hypothesis of convergence is validated at the 10% level during the period 1991-2017 among provinces. Therefore, in stable income inequality or increasing trends of inequality, we do not see the evidence of convergence; while, in a period of declining income inequality, we can detect a significant absolute convergence result. In other words, the significant negative estimator suggests that the reduction in income inequality has been accompanied by a process of convergence. Further study is still needed to analyze the causality between inequality and convergence.

7. Conclusion and discussion

The focus of this paper is to test the hypothesis of conditional convergence among Chinese provinces, evaluate the relationship between income inequality and economic growth, and analyze whether the convergence is related to income inequality.

The presence of the correlation between explanatory variables and the problems of omitted variables may produce biased results and lead to invalidating the convergence hypothesis. Considering these issues, we propose to test the conditional convergence hypothesis by comparing the result using OLS, WG, and DIF-GMM. The significant negative coefficients of the initial level of GDP for all these three methods indicate that the poor provinces will catch up with the richer ones, which confirm the conditional convergence hypothesis. Next, we applied OLS to evaluate

Table 6. Estimation of the testing convergence hypothesis during three periods

Convergence test	1959-1977	1978-1990	1991-2017
(intercept)	-0.03972	0.075253	0.59664
	(0.940)	(0.617)	(0.1135)
$lnY_{i,t-1}$	0.01121	0.007997	**-0.08462 .**
	(0.872)	(0.606)	(0.0847)

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: Author's calculation, based on NBS (1959-2017).

the relationship between fixed-effect income inequality and economic growth. The regression results do not show a significant correlation. It only suggests that higher inequality seems to lower growth. In the last part of this paper, we conclude that the reduction in income inequality has been accompanied by a process of absolute convergence.

For further estimation of the relationship between income inequality and growth, we may add more specific provincial fixed-effect covariates other than the Gini coefficient, including provincial policy and secondary-school enrollment rate, etc. Moreover, we also need more accurate and comprehensive data which can clearly demonstrate the income distribution among every household so that we can quantify more accurate Gini coefficients for each province. In addition, in section 6, we only test absolute convergence because of the shortage of data needed for testing conditional convergence. Thus, this result may present an improper estimation. In this case, if we want to get more precise results, we may need a longer extension estimation period with a comprehensive data set. Furthermore, since in this paper, we only notice that the decreasing inequality is accompanied by convergence, however, for stable and increasing inequality, we do not find the correlation of inequality and convergence. Hence, the trending of inequality is correlated to the convergence hypothesis is also worthy to reveal. Whether it is the case that similar to our results to all the countries, or it is only true in China. Further study is also needed to test the causality between income inequality and convergence. We need to test whether income inequality is a necessary and sufficient condition for convergence. That is, either the inequality causes absolute convergence, and also, the convergence lead to a change in inequality, or we may just find the evidence for one direction conclusion.

References

Ali, Ali Abdulkadir, Ali Yassin Sheikh Ali, and Mohamed Saney Dalmar. 2018. "The Impact of Imports and Exports Performance on the Economic Growth of Somalia." *International Journal of Economics and Finance* 10 (1): 110-119.

Arellano, Manuel and Stephen Bond. 1991. "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *The Review of Economic Studies* 58 (2): 277-297.

Barro, Robert J. 1991. "Economic Growth in a Cross Section of Countries." *The Quarterly Journal of Economics* 106 (2): 407-443.

———. 1998. "Human Capital and Growth in Cross-Country Regressions." *Harvard University*.

———. 1999. "Notes on Growth Accounting." *Journal of Economic Growth* 4 (2): 119-137.

Barro, Robert J., Xavier Sala-i-Martin, Olivier Jean Blanchard, and Robert E. Hall. 1991. "Convergence Across States and Regions." *Brookings Papers on Economic Activity*: 107-182.

Barro, Robert J. and Xavier Sala-i-Martin. 1990. *Economic Growth and Convergence Across the United States*. Vol. w3419 National Bureau of Economic Research, Inc, NBER Working Papers: 3419. http://search.proquest.com.proxy.lib.uwaterloo.ca/docview/56341261?accountid=14906.

Barro, Robert T. and Xavier Sala-I-Martin. 1992. *Regional Growth and Migration: A Japan-United States Comparison*. Growth and Development: New Theory and Evidence. Vol. 6. doi:https://doi.org/10.1016/0889-1583(92)90002-L.

Berg, Andrew, Jonathan D. Ostry, Charalambos G. Tsangarides, and Yorbol Yakhshilikov. 2018. "Redistribution, Inequality, and Growth: New Evidence." *Journal of Economic Growth* 23 (3): 259-305.

Bhattacharya, P. , Palacio-Torralba, J. and Li, X. (2018) On Income Inequality within China's Provinces. Chinese Studies, 7, 174-182. doi: 10.4236/chnstd.2018.72015.

Bond, Stephen and Anke Hoeffler. 2001. *GMM Estimation of Empirical Growth Models* University of Oxford, Department of Economics, Economics Series Working Papers: 2001-W21. http://search.proquest.com.proxy.lib.uwaterloo.ca/docview/1361806717?accountid=14906.

Cai, Fang, Dewen Wang, and Yang Du. 2002. "Regional Disparity and Economic Growth in China: The Impact of Labor Market Distortions." *China Economic Review* 13 (2-3): 197-212.

Cai, Fang, Dewen Wang, and Yang Du. 2002. *Regional Disparity and Economic Growth in China: The Impact of Labor Market Distortions*. Vol. 13. doi:https://doi.org/10.1016/S1043-951X(02)00072-X.

Caselli, Francesco, Gerardo Esquivel, and Fernando Lefort. 1996. "Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics." *Journal of Economic Growth* 1 (3): 363-389.

Chen, Jian and Belton M. Fleisher. 1996. "Regional Income Inequality and Economic Growth in China." *Journal of Comparative Economics* 22 (2): 141-164.

De La Croix, David and Matthias Doepke. 2003. "Inequality and Growth: Why Differential Fertility Matters." *American Economic Review* 93 (4): 1091-1113.

Démurger, Sylvie. 2001. *Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China?*. Vol. 29. doi:https://doi.org/10.1006/jcec.2000.1693.

Durlauf, Steven N., Paul A. Johnson, and Jonathan RW Temple. 2005. "Growth Econometrics." *Handbook of Economic Growth* 1: 555-677.

Fan, C. Cindy. 2006. "China's Eleventh Five-Year Plan (2006-2010): From 'Getting Rich First' to 'Common Prosperity'." *Eurasian Geography and Economics* 47 (6): 708-723. http://search.proquest.com.proxy.lib.uwaterloo.ca/docview/56690292?accountid=14906.

Galor, Oded and Joseph Zeira. 1993. "Income Distribution and Macroeconomics." *The Review of Economic Studies* 60 (1): 35-52.

Ha, Wei, Junjian Yi, Ye Yuan, and Junsen Zhang. 2016. "The Dynamic Effect of Rural-to-Urban Migration on Inequality in Source Villages: System GMM Estimates from Rural China."

China Economic Review 37: 27-39. doi:http://dx.doi.org.proxy.lib.uwaterloo.ca/10.1016/j.chieco.2015.09.002. http://search.proquest.com.proxy.lib.uwaterloo.ca/docview/1777464092?accountid=14906.

Hao, Rui and Zheng Wei. 2010. "Fundamental Causes of inland–coastal Income Inequality in Post-Reform China." *The Annals of Regional Science* 45 (1): 181-206.

Hsiao, Cheng. 2014. *Analysis of Panel Data* Cambridge university press.

Kaldor, Nicholas. 1957. "A Model of Economic Growth." *The Economic Journal* 67 (268): 591-624.

Kanbur, Ravi and Xiaobo Zhang. 1999. "Which Regional Inequality? the Evolution of rural–urban and inland–coastal Inequality in China from 1983 to 1995." *Journal of Comparative Economics* 27 (4): 686-701.

Lazear, Edward P. and Sherwin Rosen. 1981. "Rank-Order Tournaments as Optimum Labor Contracts." *Journal of Political Economy* 89 (5): 841-864.

Li, Shantong and Zhaoyuan Xu. 2008.*The Trend of Regional Income Disparity in the People's Republic of China*.

———. 2008.*The Trend of Regional Income Disparity in the People's Republic of China*.

Lu, Max and Enru Wang. 2002. "Forging Ahead and Falling Behind: Changing Regional Inequalities in post-reform China." *Growth and Change* 33 (1): 42-71.

Mankiw, N. Gregory, David Romer, and David N. Weil. 1992. "A Contribution to the Empirics of Economic Growth." *The Quarterly Journal of Economics* 107 (2): 407-437.

Naguib, Costanza. 2017. "The Relationship between Inequality and Growth: Evidence from New Data." *Schweizerische Zeitschrift Fur Volkswirtschaft Und Statistik/Swiss Journal of Economics and Statistics* 153 (3): 183-225. http://search.proquest.com.proxy.lib.uwaterloo.ca/docview/1999337278?accountid=14906.

Nickell, Stephen. 1981. "Biases in Dynamic Models with Fixed Effects." *Econometrica: Journal of the Econometric Society*: 1417-1426.

Oaxaca, Ronald L. and Iris Geisler. 2003. "Fixed Effects Models with Time Invariant Variables: A Theoretical Note." *Economics Letters* 80 (3): 373-377. doi:http://dx.doi.org/10.1016/S0165-1765(03)00121-6. http://search.proquest.com.proxy.lib.uwaterloo.ca/docview/56276024?accountid=14906.

Pedroni, Peter and James Yudong Yao. 2006. "Regional Income Divergence in China." *Journal of Asian Economics* 17 (2): 294-315.

Romer, Paul M. 1986. "Increasing Returns and Long-Run Growth." *Journal of Political Economy* 94 (5): 1002-1037. doi:10.1086/261420. https://doi.org/10.1086/261420.

Sala-i-Martin, Xavier. 1994. "Cross-Sectional Regressions and the Empirics of Economic Growth." *European Economic Review* 38 (3-4): 739-747.

Solow, Robert M. 1956. "A Contribution to the Theory of Economic Growth." *The Quarterly Journal of Economics* 70 (1): 65-94.

Villaverde, José, Adolfo Maza, and Bala Ramasamy. 2010. "Provincial Disparities in post-reform China." *China & World Economy* 18 (2): 73-95.

Xie, Y. and X. Zhou. 2014. "Income Inequality in Today's China." *Proceedings of the National Academy of Sciences of the United States of America* 111 (19): 6928-6933. doi:10.1073/pnas.1403158111 [doi].

Zhao, Xiao Bin and SP Tong. 2000. "Unequal Economic Development in China: Spatial Disparities and Regional Policy Reconsideration, 1985-1995." *Regional Studies* 34 (6): 549-561.

Zheng, Fei, Li Da Xu, and Bingyong Tang. 2000. *Forecasting Regional Income Inequality in China*. Vol. 124. doi:https://doi.org/10.1016/S0377-2217(99)00378-1.