Convergence in Income Inequality: Further Evidence from the Club Clustering Methodology across the U.S. States

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Abstract This paper contributes to the sparse literature on inequality convergence by empirically testing convergence across the U.S. States. This sample period encompasses a series of different periods that the existing literature discusses -- the Great Depression (1929-1944), the Great Compression (1945-1979), the Great Divergence (1980-present), the Great Moderation (1982-2007), and the Great Recession (2007-2009). This paper implements the relatively new method of panel convergence testing, recommended by Phillips and Sul (2007). This method examines the club convergence hypothesis, which argues that certain countries, states, sectors, or regions belong to a club that moves from disequilibrium positions to their club-specific steady-state positions. We find strong support for convergence through the late 1970s and early 1980s and then evidence of divergence. The divergence, however, moves the dispersion of inequality measures across states only a fraction of the way back to their levels in the early part of the 20th Century.

Introduction

Dew-Becker and Gordon (2005) show that from 1966-2001, only the top 10 percent of the income distribution in the United States gained real income equal to the growth in labour productivity. Gordon (2009) also argues that abundant evidence documents that US income inequality worsened since the 1970s.

Solow (1956) and Swan (1956) first proposed the convergence hypothesis as part of the neoclassical growth models. These models exemplify diminishing returns to factors of production, which predicts that per capita income in poor countries will eventually converge to that in rich countries. The convergence hypothesis sparked enormous interest and led to an extensive literature testing convergence in average incomes both within and across countries.

Bénabou (1996) noted that neoclassical growth models could imply convergence of the entire distribution of income, not just the mean. Inequality levels will fall in countries with high inequality and will rise in countries with low inequality. The idea of convergence clubs for income inequality reflects the conventional wisdom, as noted by Bénabou (1996), that Latin American countries, on average, exhibit higher income inequality than European countries, who, in turn, exhibit, on average, higher inequality than East Asian countries. That is, do these different regions represent different convergence clubs for income inequality?

This paper contributes to the sparse literature on inequality convergence by empirically testing convergence across the U.S. States, using annual state-level data from 1916 to 2012 constructed by Frank (2014). This sample period encompasses a series of different periods that existing literature discusses -- the Great Depression (1929-1944), the Great Compression (1945-1979), the Great Divergence (1980-present), the Great Moderation (1982-2007), and the Great Recession (2007-2009). Goldin and Margo (1992) identified the Great Compression as the time after the Great Depression, when income inequality fell dramatically compared to the Great Depression. Krugman (2007) described the period after

the Great Compression as the Great Divergence, when income inequality grew. Piketty and Saez (2003) claim that the Great Compression ended in the 1970s and then income inequality worsened in the U.S. Thus, we anticipate that our analysis will document convergence in income inequality through the late 1970s and then divergence in the rest of the sample.

Our study of U.S. states provides a more homogeneous test for conducting convergence tests for income inequality than a panel of countries. The United States generally exhibits lower income inequality than Latin American countries, but higher income inequality than European countries. Do the U.S. states, however, also exhibit convergence clubs in income inequality? Our tests permit the testing for the existence of convergence clubs within the United States.

The existing literature uses several alternative approaches to identify whether and when convergence occurs, with most analyses examining the convergence of per capita real GDPs across countries. Initial empirical tests of the convergence hypothesis considered β-convergence (Barro and Sala-i-Martin, 1992; Mankiw et al., 1992; Quah 1996). Without additional control variables, the test considered absolute convergence, whereas with additional control variables, the test examined conditional convergence. Tests of β-convergence generally estimate a log-linearized solution to a non-stochastic model with an additive error term. Alternatively, σ-convergence (Friedman, 1992; Quah, 1993), argues that a group of countries/sectors/regions converge when the cross-section variance of the variable under consideration declines over time. As noted by Bliss (1999; 2000), however, the underlying assumption of an evolving data distribution introduces difficulties in the interpretation of the test distribution under the null. Moreover, the rejection of the σ-convergence hypothesis does not necessarily mean that they do not converge. That is, the presence of transitional dynamics in the data can lead to the rejection of the null hypothesis of σ-convergence.

Other approaches to testing the convergence hypothesis use cointegration and unit-root tests. Cointegration and unit-root tests of convergence, owe their existence to the statistical definition of cross-country convergence of Bernard and Durlauf (1995, 1996), which states that two countries converge if their long-term forecasts are equal. According to their definition, two countries converge if their output gap is a zero mean stationary process. These tests of convergence also experience a number of serious drawbacks. Lau (1999) theoretically argues that integration and cointegration properties arise intrinsically in stochastic endogenous growth models and produce steady-state growth even in the absence of exogenous growth-generating mechanisms. In the usual I(0)/I(1) approach or the standard cointegration framework, however, researchers infrequently find evidence in favour of convergence or catching-up effects, notably across the developing economies. Pesaran (2007) extends the cointegration methodology such that it does not require the assumption of similarity in all respects for convergent countries. The main advantage of his extension is that it does not require a benchmark against which we measure convergence. According to this methodology, convergence between two countries occurs if their output gap is stationary with a constant mean.

Finally, another strand of research claims that the I(0)/I(1) setting does not provide the appropriate framework to test for convergence, since aggregate outputs are suitably modelled by fractionally integrated processes. In other words, such processes account for long-memory characteristics of the series through a differencing parameter d that can take fractional values and not only integer ones (Gil-Alana, 2001; Haubrich and Lo, 2001; Abadir and Talmain, 2002; Halket, 2005; Cunado et al., 2006; Stengos and Yazgan 2014).

Another strand of the literature examines the phenomenon of club convergence. Researchers define club convergence as the tendency of output per capita of economies to converge to multiple steady-state equilibria, one for each basin of attraction, which depend on

initial conditions. The empirical literature on the detection of convergence clubs employs a variety of statistical methods. Durlauf and Johnson (1995) dismiss the frequently used linear model that studies cross-country economic behavior in favor of multiple regimes, using a data set of 121 countries using regression tree analysis, and they find evidence for club convergence in multiple steady states. Quah (1993, 1996, 1997) examines his hypothesis of convergence clubs, viewing the evolution over time of the grouping of real per capita incomes. Hansen (2000) uses a threshold regression to sort the countries into different regimes and provides evidence to support such multiple regimes. Canova (2004) proposes a new technique for grouping converging countries in terms of real per capita income, which implies that countries exhibit multiple steady states for real per capita income. Caputo and Forte (2015) examine the club viability of the five main EMU members -- France, Germany, Italy, Spain, and the UK.

This paper implements the relatively new methodology of panel convergence testing, recommended by Phillips and Sul (2007). This method examines the club convergence hypothesis, which argues that certain countries, states, sectors, or regions belong to a club that moves from disequilibrium positions to their club-specific steady-state positions. This method, which shares a number of similarities with the fractional integrated methodological approaches of convergence, includes several appealing characteristics. First, no specific assumptions concerning the stationarity of the variable of interest and/or the existence of common factors are necessary. Nevertheless, we can interpret this convergence test as an asymptotic cointegration test without suffering from the small sample problems of unit-root and cointegration testing. Second, the method relies on a quite general form of a nonlinear time-varying factor model, where the common stochastic trends employed allow for long-run co-movements in aggregate behaviour without requiring the presence of cointegration. Third, it also permits the estimation of transitional effects. Finally, the most substantial advantage of

this method over all the previous convergence approaches is that it avoids the assumption that the convergence process needs further modelling as a time-varying transition path to long-run equilibrium, which seems relevant for the majority of developing economies, but not for emerging-market countries.

Furthermore, the methodology of Phillips and Sul (2007) does not relate solely to growth theories and can study convergence in economic and financial variables beyond output. For example, Apergis et al (2011) apply this methodology to study the convergence dynamics of international equity markets, while Kim (2015) studies convergence dynamics of electricity consumption and confirms the presence of convergence clubs. More recently, Antonakakis et al. (2017) examine the convergence patterns of Euro Area countries' sovereign bond yield spreads.

Literature Review

A number of papers in the literature describe and explain the association between inequality and a country's development. This literature begins with the seminal paper by Kuznets (1955) who provides the first piece of evidence for an inverted-U relationship between the level of a country's development and its degree of income inequality. This nonlinear relationship reflects primarily "dual economy dynamics," associated with the transition from an agricultural to an industrial economy.

In this strand of the literature, Alesina and Rodrik (1994), Perotti (1996), Persson and Tabellini (1994), and others highlight a negative relationship between these two variables, which reflects either the negative effect of inequality on education or on the presence of capital market imperfections and credit constraints. By contrast, Li and Zou (1998), Barro (2000), and Forbes (2000) document a positive relationship, reflecting either the relative savings propensities of rich versus poor or the presence of investment indivisibilities.

Lundberg and Squire (2003) argue that openness and civil liberties affect both variables in the same direction, thereby giving a positive relationship between income inequality and growth.

In a different strand of the literature, a number of studies explore income inequality convergence within the same country rather than across countries. In particular, Marina (2000) investigates 25 provinces in Argentina and finds evidence of β-convergence. Gomes (2007) reaches the same conclusion for Brazil. Panizza (2001) uncovers evidence to support the convergence hypothesis across the states in the US. Goerlich and Mas (2004) find strong evidence of β-convergence across Spanish provinces. Ezcurra and Pascual (2009) use Quah's (1996) non-parametric approach and find σ-convergence of inequality across states in the US. Lin and Huang (2011, 2012a, 2012b) investigate convergence in the US over 80 years, using data on top income shares in addition to the Gini index. Their findings show strong evidence on convergence.

Finally, other papers investigate convergence across countries; Ravallion (2003) finds that developing countries converge toward medium inequality in the 1990s. Bleaney and Nishiyama (2003) find that compared to developing countries, income distribution among OECD countries converged significantly faster and to a more equal distribution. Lopez (2004) compares convergence in income levels with convergence in inequality and finds that between 1960 and 2000, inequality within countries converged much faster than their average incomes. Rajan (2010) underscores how inequality intensifies the leverage and financial cycle, sowing the seeds for an economic crisis, while Berg and Ostry (2017) document with multi-country evidence that greater equality can help sustain growth. In a recent study, Ostry et al. (2014) provide further evidence that inequality can undermine progress in health and education, cause political and economic instability, and undercut the social consensus required to adjust in the face of major shocks, and thus further trim the intensity and duration of growth.

Hence, based on the literature related to convergence of income inequality, we can see that the analyses primarily consider the full sample of the data used. Our paper adds to this literature by taking a time-varying approach, which, besides providing full-sample information on convergence, also tracks the convergence path of each of the cross-sectional units (US states) over time. In addition, since the methodology opens the possibility of convergence clubs, important policy implications also emerge. If only one convergence club exists for the entire economy, policy makers can pursue a uniform policy for reduction of inequality across the entire country. If multiple convergence clubs exist, however, club-specific policies need to account for the commonality amongst the states comprising the specific club. Finally, since our data set covers the period of 1916 to 2012, we can also track the convergence path over the most recent abnormal episode of the "Great Recession," over and above other unique episodes spanning 87 years of history on various types of inequality measures of the US economy.

Econometric Methodology

This section outlines the methodology proposed by Phillips and Sul (2007) to test convergence in a panel of countries and to identify convergence clubs, if any. Phillips and Sul propose a new econometric approach for testing the convergence hypothesis and the identification of convergence clubs. Their method uses a nonlinear time-varying factor model and provides the framework for modeling transitional dynamics as well as long-run behavior.

The new methodology adopts the following time-varying common-factor representation for y_{it} of country i:

$$y_{it} = \delta_{it}\mu_t,\tag{1}$$

where μ_t is a single common component and δ_{it} is a time-varying idiosyncratic element that captures the deviation of country i from the common path defined by μ_t. Within this

framework, all N economies will converge, at some point in the future, to the steady state, if $\lim_{k \to \infty} \delta_{it+k} = \delta$ for all i = 1, 2, ..., N, irrespective of whether countries are currently near the steady state or in transition. This is an important point given that the paths to the steady state (or states) across countries can differ significantly.

Phillips and Sul (2007) test whether economic variables y_{it}, i = 1, 2, ..., N converge to a single steady state as $t \to \infty$. Thus, they adopt a factor representation $y_{it} = \delta_{it}\mu_t$ (Eq. 1) for each economic variable in the sample. The factor μ_t is assumed common across individuals (economies), while the transition dynamics are captured by the idiosyncratic components δ_{it}, which can vary across cross-section units and time. Convergence is a dynamic process. Since δ_{it} traces the transition paths, we examine convergence through temporal relative evolution of δ_{it}. Phillips and Sul (2007) do not assume any parametric form for μ_t; they just factor it out and concentrate on δ_{it}.

Since we cannot directly estimate δ_{it} from Eq. (1) because the number of parameters exceeds the number of observations, Phillips and Sul (2007) assume a semiparametric form for δ_{it}, which enables them to construct a formal test for convergence. In particular, they eliminate the common component μ_t through rescaling by the panel average:

$$h_{it} = \frac{y_{it}}{\frac{1}{N}\sum_{i=1}^{N} y_{it}} = \frac{\delta_{it}}{\frac{1}{N}\sum_{i=1}^{N} \delta_{it}}. \tag{2}$$

The relative measure h_{it} captures the transition path with respect to the panel average. Defining a formal econometric test of convergence as well as an empirical algorithm of defining club convergence requires the following assumption for the semi-parametric form of the time-varying coefficients δ_{it}:

$$\delta_{it} = \delta_i + \sigma_{it}\xi_{it}, \tag{3}$$

where $\sigma_{it} = \dfrac{\sigma_i}{L(t)t^{\alpha}}$, $\sigma_i > 0$, $t \geq 0$, and ξ_{it} is weakly dependent over t, but iid(0,1) over i.

The function $L(t)$ varies slowly, increasing and diverging at infinity.[1] Under this specific

form for δ_{it}, the null hypothesis of convergence for all i takes the form:

H_0 : $\delta_i = \delta$, $\alpha \geq 0$, while the alternative hypothesis of non-convergence for some i takes

the form: H_A : $\delta_i \neq \delta$ or $\alpha < 0$. Phillips and Sul (2007) show that we can test for the

null of convergence in the framework of the following regression:[2]

$$\log\left(\frac{H_1}{H_t}\right) - 2\log L(t) = \hat{c} + \hat{b}\log t + \hat{u}_t, \qquad (4)$$

for $t = [rT]$, $[rT]+1$, ..., T, and $r > 0$.[3] In this regression, $H_t = \dfrac{1}{N}\sum_{i=1}^{N}(h_{it}-1)^2$ and $\hat{b} = 2\hat{\alpha}$,

where h_{it} is defined in Eq. (2) and $\hat{\alpha}$ is the least squares estimate of α. Under the null

hypothesis of convergence, the dependent variable diverges whether $\alpha > 0$ or $\alpha = 0$. In this

case, we can test the convergence hypothesis by a t-test of the inequality, $\alpha \geq 0$. The t-test

statistic follows the standard normal distribution asymptotically and is constructed using

heteroskedastic and autocorrelation consistent standard errors. Phillips and Sul (2007) call the

one-sided t-test, which is based on $t_{\hat{b}}$, the $\log t$ test due to the presence of the $\log t$ regressor

in Eq. (4).[4]

The empirical convergence literature also deals with the possible existence of multiple

equilibriums. In that case, rejection of the null hypothesis that all countries in the sample

converge does not imply the absence of convergence clubs in the panel. In this study, we

implement the club convergence and clustering procedure proposed by Phillips and Sul

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[1] In this paper, we set $L(t) = \log t$.

[2] Appendix B of Phillips and Sul (2007) reports the analytic proof under the convergence hypothesis for this regression equation.

[3] Following the recommendation of Phillips and Sul (2007), we choose r values in the interval [0.2, 0.3].

[4] The log t test exhibits favorable asymptotic and finite sample properties.

(2007). That procedure involves the following steps. (1) Order the N countries with respect to the last-period value of the time series. For example, in the case of GDP per capita, we order the countries in a descending order with the first country having the highest last period income, the second with the next highest income, and so on. (2) Form all possible core (club) groups C_k by selecting the first k highest countries, with $k = 2, 3, ..., N$. Then, test for convergence using the $\log t_k$ test within each subgroup of size k. Finally, define the core club C^* of size k^* as the club for which the maximum computed $\log t_{k^*}$ statistic occurs, given that the $\log t_k$ statistic supports the convergence hypothesis. (3) From the remaining N-k^* countries, add one country at a time to the core club C^* and test for convergence through the $\log t$ test. If the test strongly supports the convergence hypothesis ($\log t \geq 0$), then include the country in group C^*. Find all countries that, according to the $\log t$ test, converge to the same steady state with the core group C^*. These countries together with the countries of the core group C^* form the first convergence club in the panel. (4) Then, for the remaining countries (if any), repeat the procedure described in steps 1-3 to determine the next convergence club, if one exists. Finally, terminate the procedure when the remaining economies fail to converge.

Data

This study also makes use of alternative measures of income inequality constructed by Frank (2014).[5] These measures include the share of total income held by the Top 10% of the income distribution and the Gini coefficient, covering the annual period of 1916-2012.[6]

The metrics that use different (percentage) shares of total population are simple comparisons across different income groups, ranked according to income ranges. Their advantages include simpleness to compute and easy to interpret and explain. Their drawbacks are only sensitive to changes in the two compared income shares, so they do not depict overall changes in within distribution, while they do not provide an absolute measure of income inequality, because they do not fall into an absolute scale of measurement. Finally, their measure can be skewed due to outliers in the distribution and they do not weight the included observations.

The Gini coefficient can compare different income distributions of different groups of populations (i.e., countries, states, regions) based on the Lorenz curve. Lundberg and Squire (2003) note that the Gini coefficient does not convey any information about the shape of the Lorenz curve. Moreover, this index provides a point estimate of the income distribution and does not capture the lifetime income of a person, which changes over time and can affect its position within the income distribution.

Empirical Analysis

Convergence

Table 1 reports results for the shares of income held by the Top 10% of the national population. The first row reports the test for full convergence (i.e., convergence among all 48 States and DC), while rows 2 and 3 display the results of the club clustering procedure. The results of the full sample reject the null hypothesis of income inequality convergence, since the $\log(t)$ statistic is -5.532 (with critical value of -1.67). The formation of the two different convergence clubs shows that there exist two clubs of 12 and 37 States and DC, respectively.

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version of this paper, we also discuss the findings from these additional four measures of inequality. See https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2623724.

Table 1. Income inequality convergence-Top10% share of the population approach over 1916-2012

Group	States	t-stat
Full sample	Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming	-5.532
1st club	California, Connecticut, Delaware, District of Columbia, Florida, Illinois, Massachusetts, Nevada, New Jersey, New York, Texas, Wyoming	3.721
2nd club	Alabama, Arizona, Arkansas, Colorado, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin	2.985

Source: Own calculations based on Phillips and Sul (2007, 2009), and Frank (2014).

Table 2 reports the results of the panel convergence methodology for the Gini income inequality index. This time the results seem different. The first row reports the test full convergence (i.e., convergence among all States and DC), while rows 2 and 3 display the results for the club clustering procedure. The full sample rejects the null hypothesis of income inequality convergence, since the log(t) statistic is -3.656 (with critical value of -1.67). The formation of the two different convergence clubs leads to two clubs of 30 and 19 members, respectively.

Comparing the lists of 48 States and DC in the two clubs in Tables 1 and 2 leads to the following observations. All members of club 1 in Table 1 for the Top 10% inequality measure also appear in club 1 in Table 2 for the Gini coefficient, but 18 States moved from club 2 in Table 1 to club 1 in Table 2. Thus, all 19 members in club 2 for the Gini coefficient also appear in club 2 for the Top 10% measure.

Table 2. Income inequality convergence-Gini index over 1916-2012

Group	States	t-stat
Full sample	Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming	-3.656
1st club	Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Louisiana, Massachusetts, Michigan, Mississippi, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Utah, Washington, Wyoming,	3.211
2nd club	Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Minnesota, Missouri, New Hampshire, North Carolina, North Dakota, Ohio, Oregon, Rhode Island, South Carolina, Vermont, Virginia, West Virginia, Wisconsin	8.445

Source: Own calculations based on Phillips and Sul (2007, 2009), and Frank (2014).
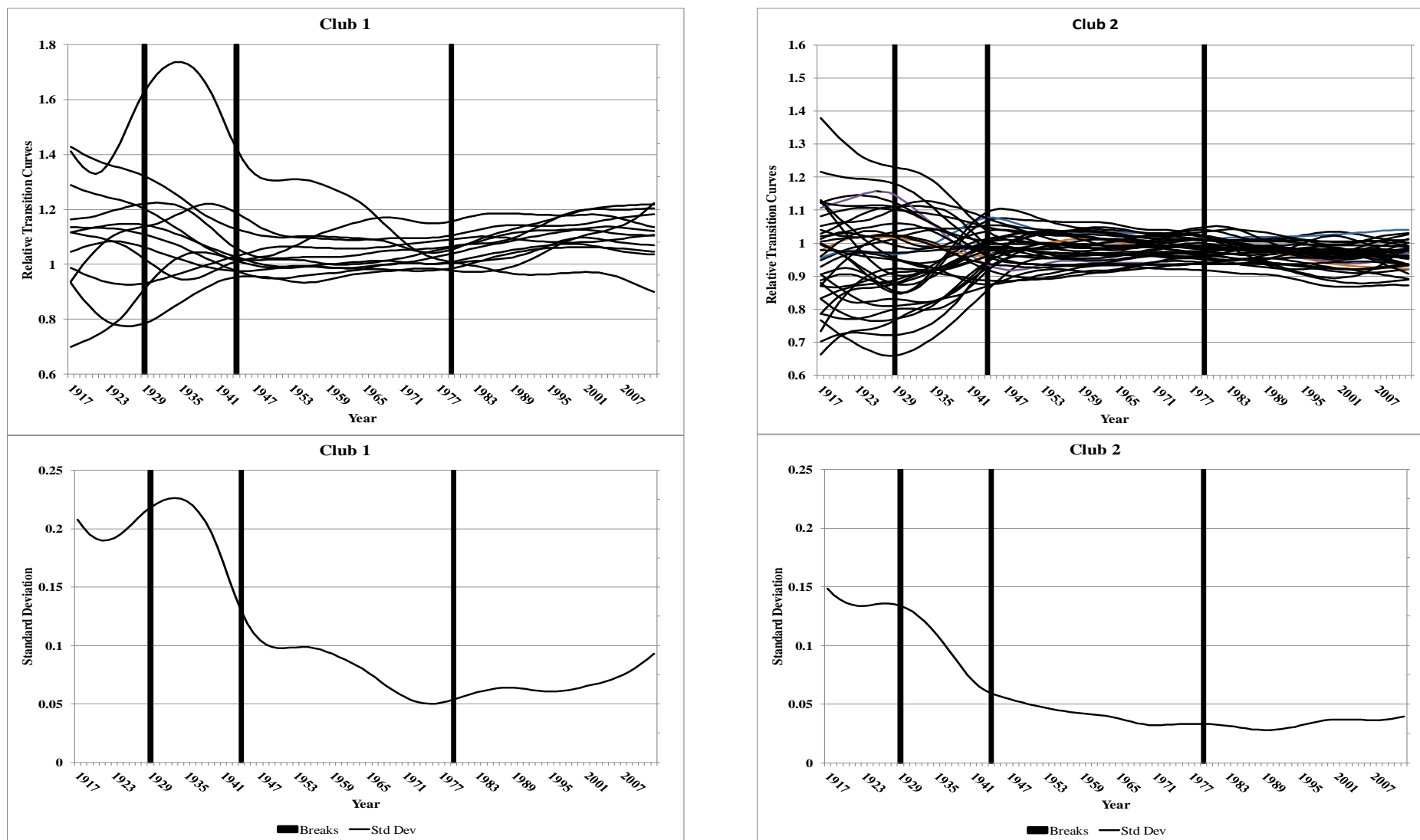
Relative Transition Curves and Their Dispersion

Following Phillips and Sul (2007), we alternatively estimate the relative transition measures, h_{it}, defined in Eq. (2), which capture the transition paths with respect to the panel average. Figs. 1 and 2 display the relative transition curves and the standard deviation of those transition curves at each point in time for the convergence clubs associated with the two income inequality indexes.

Fig. 1 shows the transition curves and their standard deviation for the Top 10% measure of inequality for the two convergence clubs.[7] Club 1 and 2 both experience convergence until the late 1970s and early 1980s, respectively. The transition curves in the upper half of Fig. 1 illustrate β-convergence, which we see occurring through the 1970s when convergence appears to end. The standard deviation curves in the lower part of Fig. 1
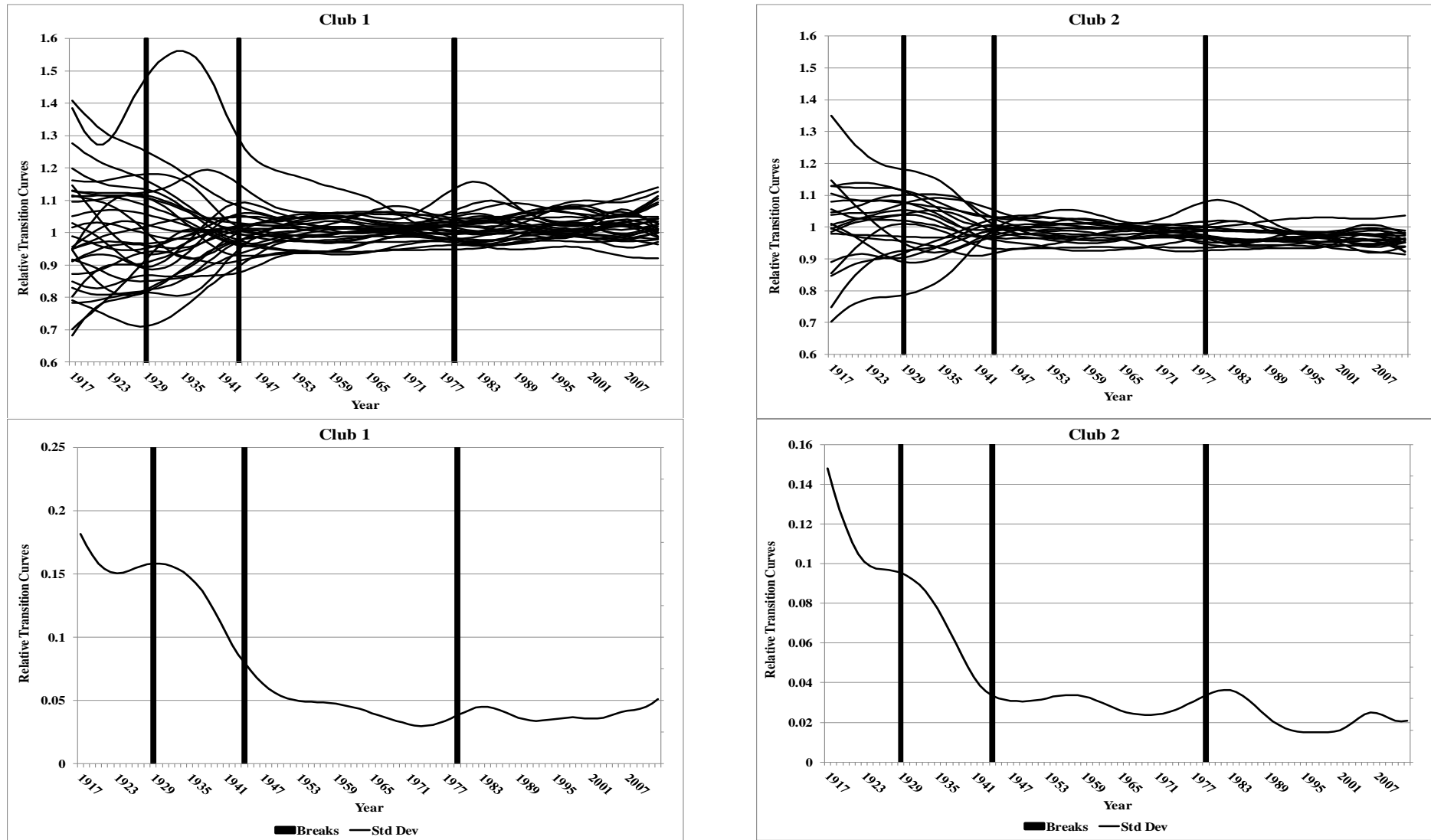
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[7] The solid vertical lines divide the sample period into the WWI and "Roaring 20s" (1916-1928), the Great Depression (1929-1944), the Great Compression (1945-1979), and the Great Divergence (1980-2012).

Fig. 1. Relative Transition Curves and Standard Deviations: Top10% Inequality Measure, 1916-2012

Source: Own calculations based on Phillips and Sul (2007, 2009), and Frank (2014).

Fig. 2. Relative Transition Curves and Standard Deviations: Gini Index, 1916-2012

Source: Own calculations based on Phillips and Sul (2007, 2009), and Frank (2014).

illustrate σ-convergence, which decline and bottom out in the late 1970s or early 1980s and then does not alter that much.

Fig. 2 displays the transition curves and their standard deviation for the Gini coefficient measure of inequality for the two convergence clubs. The transition curves and standard deviations tell similar stories to those for the Top 10% information in Fig. 2. We noted above that 18 states moved from club 2 for the Top 10% measure to club 1 for the Gini coefficient. As before, the upper graphs in Fig. 2 illustrate β-convergence, which we see occurring through the early 1950s when convergence appears to end. The standard deviation curves in the lower part of Fig. 1 illustrate σ-convergence, which decline and slow down or stop in the early 1950s and then does not change much after that.

Club 1 in both Tables 1 and 2 represent states with more income inequality, on average.[8] In Fig. 1, the convergence of the states in Club 1 occurs between just above 1.0 and just above 1.2 with the exception of Delaware, while the convergence of the states in Club 2 occurs between just below 0.9 and just above 1.0. That is, states in Club 1 experience a higher level of inequality than states in Club 2, measured by the Top 10%. In addition, for the Top 10% measure of inequality Club 1 includes mostly high-income states.[9]

In Fig. 2, the convergence of the states in Club 1 occurs between just below 1.0 and just above 1.1 with the exception of Delaware, while the convergence of the states in Club 2 occurs between just above 0.9 and just below 1.0. Thus, once again, states in Club 1 experience a higher level of inequality than states in Club 2, measured by the Gini. In addition, for the Gini coefficient measure of inequality, Club 1 includes mostly high-income states, although the relationship is weaker when compared to the Top 10% inequality

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[8] Figs. 1 and 2 plot the transition curves, which measure the inequality measure (i.e., Top 10% and Gini coefficient) relative to the average inequality measure across all states. See Eq. (2).
[9] We also performed the Philips-Sul (2007) method to identify convergence clubs for annual real personal income per capita from 1929 to 2012. The method identifies two convergence clubs whereby the states in Club 1 come from the highest income states (i.e., 7 of the top 11 states ranked by income). Results are available from the authors on request.

measure. This probably reflects the fact that the Top 10% focuses on the higher end of the income distribution, whereas the Gini coefficient captures the entire income distribution.

Robustness Tests

Phillips and Sul (2009) argue that their convergence club methodology tends to find more members of clubs than their true number. To avoid this over-determination, they run the algorithm across the sub-clubs to assess whether any evidence exists to support the merging of smaller clubs into larger clubs. Tables 3 and 4 report the results of the new convergence tests for the two indices. Following Phillips and Sul (2009), we consider adjacent sub-clubs and the column "tests of club-merging" reports the fitted regression coefficient. The empirical findings imply that across all five indexes of income inequality and across all sub-clubs, no evidence supports mergers of the original clubs.

Table 3.　　　Convergence club classification-Income inequality index: Top10% share of the population approach over 1916-2012

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Club	Tests of club merging

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| 1 | Club 1+2 = 1.116* |
| | (5.73) |

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* 　　denotes statistical significant at the 5% level, while it rejects the null hypothesis of merging. Numbers in parenthesis denote t-statistics. Source: Own calculations based on Phillips and Sul (2007, 2009), and Frank (2014).

Table 4.　　　Convergence club classification-Income inequality index: Gini over 1916-2012

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Club	Tests of club merging

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| 1 | Club 1+2 = 1.458* |
| | (6.35) |

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* 　　denotes statistical significant at the 5% level, while it rejects the null hypothesis of merging. Numbers in parenthesis denote t-statistics. Source: Own calculations based on Phillips and Sul (2007, 2009), and Frank (2014)

Conclusion

This paper implements the Phillips and Sul (2007) method of testing for club convergence. The club convergence hypothesis argues that groups of countries, states, sectors, or regions from a club that moves units from disequilibrium positions to their club-specific steady-state

equilibrium positions. This paper contributes to the sparse literature on inequality convergence by empirically testing convergence of different inequality measures -- the share of total income held by the top 10 percent of the income distribution and the Gini coefficient -- across the U.S. States. This sample period from 1916 to 2012 includes a numbers of different episodes that the existing literature discusses -- the Great Depression (1929-1944), the Great Compression (1945-1979), the Great Divergence (1980-present), the Great Moderation (1982-2007), and the Great Recession (2007-2009).

We find strong support for convergence through the late 1970s and early 1980s and then evidence of divergence. The divergence, however, moves the dispersion of inequality measures across states only a fraction of the way back to their levels in the early part of the 20th Century. More specifically, two convergence clubs exist for the Top 10% as well as for the Gini coefficient. Each of the clubs relates to the clubs in the other inequality measures with some modifications in membership.

One possible direction for future research examines the relationship between national- and state-level inequality measures.[10] For example, does cross-club inequality account for more of the national inequality than within-club inequality? We intend to pursue this and other related new research questions in future work.

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[10] One referee suggested this line of research.

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