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Income inequality may not converge after all: Testing panel unit roots in the presence of cross-section cointegration

Tsung-wu Ho

Department of Finance, Shih Hsin University, No. 111, Sect. 1, Mu-cha Road, Taipei 11604, Taiwan, ROC

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ABSTRACT

This paper empirically examines whether there exists stochastic convergence of income inequality among 48 contiguous US states from 1916 to 2012. To control long-run cross-section dependency in panel data, we apply the orthogonal instrument generating approach of Chang and Song (2009) to test unit root. Our results, unlike the literature, do not support the convergence hypothesis. Moreover, we confirm that long-run cross-section correlation has substantial impacts, which are robust to all inequality measures as well as quantile differentials. In addition, although there is a given rising trend, the income distribution of the United States is state-specific and does not converge to either the national level or the state-average.

1. Introduction

Over the past quarter century, income inequality in the United States has been rising. For example, Piketty and Saez (2003). This increasing trend of inequality in the US has been widely discussed in the past decades. Several studies, such as Cutler and Katz (1992) and Lee (1999), have indicated that the *skill-biased* technological change shifts the relative labor demand against *less-skilled* workers, and as a result, the changes in the distribution of labor-market earnings widen the gap. On the other hand, since factor income is a function of factor price (labor and capital), high factor mobility and public transfers can be the possible forces that make inequality across the 48 contiguous states converge over time, and Panizza (2001) offers supportive empirical evidence.

However, the underlying forces of convergence in Panizza (2001) can be sources of long-run cross-section dependency in the panel data, hence, it may not imply convergence after all. That is, although states with similar fundamentals may co-move, it can merely result in cross-section long-run dependency; therefore, just like de-mean and de-trend methods, the convergence hypothesis has to be examined in the presence of such dependency.

Therefore, to account for the effects of both short- and long-run cross-section dependency on panel unit root test, this paper contributes to the literature by applying the orthogonal instrumental generating function approach, proposed by Chang and Song (2009), to test the unit root of a panel of 48 contiguous states in the United States. In the econometrics literature, the cross-section dependency is mainly modeled by a weak form,[1] namely a short-run cross-section correlation. When both short- and long-run cross-section correlation are accounted for, we show that the inequality convergence hypothesis does not hold after all, and the income distribution or inequality of each state has its own stochastic trend.

Bénabou (1996) explains that the reason empirical evidence of the convergence (or divergence) of income inequality is of particular interest is that: once augmented with idiosyncratic shocks, the neoclassical growth model implies convergence not only in per capita income level, but also in income distribution. That is, the analysis of convergence in income inequality can be considered as an extension of the growing literature that investigates convergence in per capita income.

E-mail address: tsungwu@cc.shu.edu.tw

[1] For instance, Chang (2002), and Pesaran (2007).

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Several empirical studies have been devoted to the investigation of the issue of convergence in income inequality among different economies. For instance, for cross-country studies, Bénabou (1996) and Ravallion (2003) use the Gini index as a measure of inequality, and find evidence in support of inequality convergence among various countries. Additionally, Bleaney and Nishiyama (2003) find that income distributions converge faster among advanced countries. Furthermore, Ravallion (2003) points out the heterogeneous problem associated with the use of international data, so some studies have turned to the use of regional and within-nation data; for instance, Ezcurra and Pascual (2005) and Tselios (2009) use the European Community Household Panel data survey, and find the presence of inequality convergence. Moreover, for within-nation studies, Panizza (2001) and Ezcurra and Pascual (2009) apply different techniques to test for convergence of inequality for the 48 US states, both studies confirm the presence of convergence in income inequality. Panizza (2001) uses OLS and GMM to estimate data and test the convergence hypothesis, but cross-section dependency is ignored. Although Ezcurra and Pascual (2009) consider cross-section dependency, which is not a long-run type.

In the applied econometrics literature, two types of tests are used to check for the presence of econometric convergence. The first framework examines a long run dynamic relationship between an individual region and its reference unit, where specifically, a unit root or cointegration test is conducted to test the hypothesis of convergence over time, e.g., Carlino and Mills (1993), Bernard and Durlauf (1995), Oxley and Greasley (1995).

The second approach extends the time series approach to panel data. Given a panel of samples, Evans and Karras (1996) and Evans (1998)[2] investigate the notion of stochastic convergence as follows: The first step is to compute the deviation of individual time series from its cross-section mean, for example $y_{it} = Y_{it} - M_t$, where M_t denotes the cross-section average at time t. Then, the second approach tests the stationarity of y_{it} to infer convergence to the cross-section mean. We name the series y_{it} by *mean differentials*, and its stationarity by *cross-section convergence* to distinguish it from pure time series convergence seen in, for instance, Fleissig and Strauss (2001), and Guetat and Serranito (2007). Many other studies have employed similar methods. For example, in a study of herding, Gleason, Mathur, and Peterson (2004) examined whether individual ETF returns deviate from the market returns. Arghyroua, Gregorioub, and Kontonikasc (2009) studied EU market integration by investigating whether the country-specific real interest rates deviate from the EU average, and Lin and Huang (2012) examined the inequality convergence in panel data.

For inequality in this study, stationarity of *mean differentials* y_{it} indicates that all these states move toward a common distribution of income, which could be either in an increasing or a decreasing trend. Hence, mean differentials stationarity does not posit anything about whether inequality is deteriorating or not. We further the study by testing differentials from quantiles. Moreover, instead of state average, we also use national level data of Top 10 and Top 1 to evaluate the possibility of national convergence.

2. Econometric methodology

2.1. The problem of panel unit root tests

Panel unit root tests have been one of the most active research areas in econometrics for the past several years. This is largely due to the availability of panel data with long time spans. In addition, there has been an increasing use of cross-country and cross-region data over time, to test for many important inter-relationships, especially those involving the convergence of various economic variables. The notable theoretical contributors on the subject include Maddala and Wu (1999), Chang (2002, 2004), Levin, Lin, and Chu (2002), and Im, Pesaran, and Shin (2003). There have been numerous related empirical researches as well, for instance, MacDonald, Oh, and Papell.[3]

Estimation of the integrated series in panel data is straightforward, but inference is complicated because cross-section dependency is hard to deal with in $I(1)$ data. O'Connell (1998) shows that the ignored cross-section dependence in the data greatly distorts the size of panel unit root tests. However, cross-section correlation is either assumed away (Harris & Tzavalis, 1999; Im et al., 2003; Levin et al., 2002) or parameterized as a specific form of contemporaneous correlation.

As indicated by Quah (1993), modeling cross-section dependence is more complicated because, unlike pure time-series models, individual observations in cross-section units display no natural ordering. In the presence of cross-section dependency, the usual Wald-type unit root test based on the OLS and GLS system estimators have limit distributions that are dependent in a very complicated way upon various nuisance parameters defining the correlations across individual units.

To solve this problem, Chang (2002) extends a nonlinear IV approach of Phillips et al. to panel data, which shows that the product of the nonlinear instruments from different cross-sectional units i and j are asymptotically *uncorrelated*, even when the variables generating these instruments are correlated. This implies that the individual IV t-ratio statistics constructed from the non-linear IV's are asymptotically independent. This asymptotic orthogonality plays a crucial role in developing a limit theory for the panel unit root test statistic, whose distribution is shown to be asymptotically standard normal, which means it does not require tabulation of the critical values.

However, only weak cross-section dependency is allowed in Chang (2002). Chang and Song (2009) propose instrument non-linear transformations of the lagged levels to test for unit roots in panels with general dependency and heterogeneity across cross-section unit, which allow not only for the cross-section dependencies of innovations, but also for the presence of co-integration across cross-sections. Namely, both short-run correlation and long-run cointegration across countries are allowed.

In Chang and Song (2009) the cross-section cointegration is dealt with by using an orthogonal set of functions as instrument generating functions (IGF thereafter). If a set of orthogonal IGF (OIGF therefore) are used, the resulting IV t-ratios become asymptotically normal and independent, in the presence of co-integration as well as in the cross-correlation of the error terms.

Their approach has several novel aspects. First, they allow for the presence of co-integration across cross-sectional units, as well as for the cross-section dependencies of innovations. The presence of co-integration introduces long-run cross-section dependencies in levels, whereas the cross-section dependencies in innovations are of a short-run nature. Chang and Song (2009) therefore permit cross-section dependencies both in the short- and in the long-run. It appears that there is a high potential for such possibilities in many panels of practical interests. However, none of the existing tests is applicable for such panels. In particular, they all require the absence

[2] Before them, in the field of finance, Christie and Huang (1995) propose a similar method to study herding.

[3] The papers by Phillips and Moon and Baltagi and Kao provide extensive surveys on the recent developments on the testing for unit roots in panels. See also Choi and Phillips and Sul for some related work in this line of research.