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A panel data approach to the income convergence among Mainland China, Hong Kong and Macao

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This paper provides empirical evidence in support of income convergence among Mainland China, Hong Kong and Macao in the postreform era of Mainland China. Adopting the multieconomy income convergence model and employing the panel unit root testing techniques, this paper finds that relative incomes of Mainland China, Hong Kong and Macao have no tendency to deviate from one another in the long run. The occurrence of income convergence among these Chinese economies can be attributed to rapid growth on the Mainland China and Macao sides but relatively sluggish performance of Hong Kong in recent years. Macao can be regarded as playing a catalytic role in this long-run income convergence process. The finding of convergence indicates promising prospects for deepening economic cooperation and integration among the Chinese economies for their long-run sustainable economic growth.

Keywords: China; income convergence; panel unit root

JEL classifications: C33, O53, R11

1. Introduction

Mainland China has experienced tremendous success in its economic reforms. The liberalization and open-door policies have brought about an average annual real gross domestic product (RGDP) growth rate of more than 9% in the past three decades. This eye-catching performance can hardly be found in the rest of the world and has been regarded as a miracle and role model of economic reform and development. In the process of economic reforms, economic linkages between Mainland China and the two Special Administrative Regions (SARs) of Hong Kong and Macao have become ever tighter, as these territories have been playing crucial roles in facilitating all kinds of economic activities between Mainland China and the rest of the world. Trade turnovers with Hong Kong and Macao, for example, have climbed up from \$6.49 billion and \$0.27 billion in 1982 to \$166.09 billion and \$2.44 billion in 2006, respectively. During the same time period, the actually used foreign direct investment (FDI) injected by these territories has increased from \$955.68 million to \$22,795.64 million.¹ It is commonly believed that trade and capital flows imply a transfer of technology and experience such that the relatively backward Mainland China may be able to upgrade its technology and productivity level, thereby leading to an acceleration of growth pace and a reduction in income gap with the relatively richer Hong Kong and Macao. In other words, there may be a tendency for the income levels of these economies to converge with one

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another over time. Notwithstanding, empirical evidence on the occurrence or nonoccurrence of income convergence among these Chinese economies is scarce.

Income spatial disparities within Mainland China in both the prereform and postreform periods have caught the attention of researchers and have been studied extensively in the literature. For instance, using the cross-sectional approach, the issue of income convergence within Mainland China has been investigated by Chen and Fleisher (1996), Jian *et al.* (1996), Gundlach (1997), Raiser (1998), Démurger (2001) and Yao and Zhang (2001), to name a few. The cross-sectional notion of income convergence posits that initially poorer economies grow faster than initially richer ones. An inverse relationship between the initial per capita income levels and their subsequent growth rates is taken as evidence of convergence (Barro 1991, Barro and Sala-i-Martin 1992, Mankiw *et al.* 1992). However, the cross-sectional approach to income convergence is subject to bias. According to Quah (1993), Durlauf and Johnson (1995) and Bernard and Durlauf (1996), this sort of inverse relationship may also be consistent with income divergence. Studies such as Yao and Zhang (2001), Zhang *et al.* (2001) and Pedroni and Yao (2006) have taken an alternative route and addressed the issue of income convergence in the time-series context based on the notion of stochastic convergence first suggested by Carlino and Mills (1993). Economies are said to be converging in the long run if their per capita incomes do not deviate from one another arbitrarily; that is, their incomes stochastically converge. Their per capita income disparities follow stationary processes, which means that external shocks only have temporary effects and will not lead to permanent deviations in any tendency toward convergence. Other approaches, such as the system generalized method of moments (Weeks and Yao 2003), metric entropy measure (Maasoumi and Wang 2008) and Markov transition matrix (Sakamoto and Islam 2008), have also been employed to investigate the possibility of income convergence in Mainland China.

Integrated studies on income convergence that pool up Mainland China, Hong Kong and Macao in the prereform period of Mainland China are generally lacking. As Chinese economies under foreign administration, the economic systems of Hong Kong and Macao were significantly different from that of Mainland China. Furthermore, the income levels of Hong Kong and Macao were substantially higher than that of Mainland China. Given such variations, divergence on economic performance was generally expected, and income convergence among these Chinese economies became almost impossible to be achieved. Consequently, cross-economy comparison for this time period is rarely made. However, with the ongoing process of economic reforms of Mainland China and the handovers of Hong Kong and Macao, the possibility of income convergence among them in the postreform period cannot be overlooked. Lei and Yao (2008), to the best of our knowledge, is the only study in the literature that has ever investigated such a possibility. It can be noted that works such as those of Sung (2005) and Cheung *et al.* (2007) have probed into the economic and financial integration among Mainland China, Hong Kong and Taiwan but not the income convergence issue among these Chinese economies per se.

This paper aims to shed light on the issue of income convergence among Mainland China, Hong Kong and Macao, following the work of Lei and Yao (2008), who have employed the stochastic convergence approach of Carlino and Mills (1993) in their study. Using the univariate unit root testing method, Lei and Yao (2008) find that while the bilateral income ratio between Mainland China and Hong Kong is nonstationary, that between Mainland China and Macao is stationary. Thus, their results fail to lend support to converging income between Mainland China and Hong Kong, albeit the evidence for income convergence between Mainland China and Macao. Making use of more recent data, this paper revisits the income convergence issue among Mainland China, Hong Kong and

Macao in the time-series context. Unlike Lei and Yao (2008), the issue is investigated from the multilateral perspective rather than the bilateral one. Also, the panel unit root testing techniques are employed instead of their univariate counterparts in empirical analysis.

The remaining part of the paper is organized as follows. Section 2 describes the multi-economy income convergence model, the panel unit root tests and data used in this paper. Section 3 gives an account of the growth patterns of Mainland China, Hong Kong and Macao during the sample period and presents the test results from the implementation of the panel unit root tests. Section 4 interprets the findings of Section 3 and discusses the implications drawn, whereas Section 5 concludes this paper and provides policy suggestions.

2. Methodology and data

2.1. Methodology

To investigate whether income is converging among Mainland China, Hong Kong and Macao, we employ the time-series approach of Carlino and Mills (1993), which has also been used to study income convergence among the US regions (Carlino and Mills 1993, Lowey and Papell 1996), Organisation for Economic Co-operation and Development (OECD) countries (Li and Papell 1999), Mainland Chinese provinces (Yao and Zhang 2001, Zhang *et al.* 2001) and Latin American countries (Galvão and Reis Gomes 2007), for instance.

Consider a group of N economies. Let x_{it} denotes the per capita gross domestic product (GDP) of economy i , where $i = 1, \dots, N$, at time t with $t = 1, \dots, T$; \bar{x}_t stands for the average of the per capita incomes of these N economies at time t and x_{it}^R represents the relative income of economy i to the average income of the group, that is, x_{it}^R relative to \bar{x}_t . Assume that there is a time-invariant compensating differential equilibrium level of x_{it}^R , determined by cross-economy differences in factors such as investment in physical and human capital, depreciation rate and openness to foreign countries, which, over time, each economy is moving toward. The log of x_{it}^R , y_{it} , is therefore made up of two components, namely the time-invariant equilibrium differential y_i^e and the deviations from this equilibrium v_{it} :

$$y_{it} = y_i^e + v_{it}, \quad (1)$$

where v_{it} is modeled as

$$v_{it} = v_{i0} + \beta_i t + u_{it}, \quad (2)$$

with v_{i0} standing for the initial deviation from equilibrium, β_i representing the deterministic rate of convergence and u_{it} being a stochastic process. Convergence requires that economies initially below their equilibrium differentials ($v_{i0} < 0$) grow faster than the group average ($\beta_i > 0$) and that economies initially above their equilibrium differentials ($v_{i0} > 0$) grow slower than the group average ($\beta_i < 0$).

Combining Equations (1) and (2) and letting $\mu_i = y_i^e + v_{i0}$ give

$$y_{it} = \mu_i + \beta_i t + u_{it}. \quad (3)$$

On the basis of Equation (3), convergence as defined above is translated into the requirement that for economies with initial incomes below (above) average, or negative (positive) initial y_{it} and $\mu_i < 0$ ($\mu_i > 0$), y_{it} should grow positively (negatively) and $\beta_i > 0$ ($\beta_i < 0$) (Carlino and Mills 1993, Tomljanovich and Vogelsang 2002, Dawson and Sen 2007).

For convergence to take place in the deterministic manner as described, any deviations from relative trend growth, u_{it} , must be temporary. In other words, relative income y_{it} should follow a stationary process, which is the notion of stochastic convergence. The stochastic process u_{it} can be modeled as a general autoregressive-moving average (ARMA) process represented by $A_i(L)u_{it} = B_i(L)\varepsilon_{it}$, where $A_i(L)$ and $B_i(L)$ are polynomials in the lag operator L of order p_i and q_i , respectively, and ε_{it} is a sequence of independent and identically distributed innovations.² If all the roots of $A_i(L)$ are strictly outside the unit circle, u_{it} and, therefore, y_{it} are stationary processes. They are nonstationary if $A_i(L)$ has one unit autoregressive root and all other roots are outside the unit circle. Approximating this ARMA representation by an autoregressive (AR) one (k_i), the following test equation of the augmented Dickey–Fuller (ADF) type for economy i is obtained:

$$\Delta y_{it} = \alpha_i + \gamma_i t + \phi_i y_{i,t-1} + \sum_{j=1}^{k_i} c_{ij} \Delta y_{i,t-j} + \varepsilon_{it}. \quad (4)$$

Testing for stochastic convergence then amounts to testing for the stationarity of y_{it} based on Equation (4).

In this regard, instead of using the univariate ADF test, the panel unit root tests developed by Levin *et al.* (2002, hereafter LLC), Im *et al.* (2003, hereafter IPS) and Maddala and Wu (1999, hereafter MW) are employed. Through the pooling of time-series observations across various cross sections, these panel tests have been shown to be more powerful than the underlying univariate ADF test. Under the null of a unit root, $\phi_i = 0$ for all i in Equation (4). Under the alternative of stationarity, while LLC assume a common AR coefficient for all cross sections, that is, $\phi_1 = \phi_2 = \dots = \phi_N = \phi < 0$, IPS and MW allow for heterogeneous AR coefficients, that is, $\phi_i < 0$ for some i . Thus, the panel unit root testing of LLC is based on a pooled estimator, whereas that of IPS and MW is based on a combination of test evidence across cross sections. While IPS construct a group mean test by combining the individual ADF statistics, MW propose a Fisher-type test that pools the p -values of the individual ADF test statistics. All the three panel tests follow the standard normal distribution asymptotically under the assumption of cross-sectional independence.

2.2. Data

The data-set employed in this paper consists of annual per capita GDP data for 30 Mainland Chinese provinces, Hong Kong SAR and Macao SAR between 1982 and 2006. The starting year of the sample period is constrained by the unavailability of official data for Macao prior to 1982. The income data of Mainland Chinese provinces, Hong Kong and Macao are extracted from, respectively, the *China Statistical Yearbook* (National Bureau of Statistics of China 1980–2007), *Hong Kong Monthly Digest of Statistics* (Hong Kong SAR Government 1967–2007) and the *Yearbook of Statistics of Macao* (Macao SAR Government 1982–2007). In analysis, all income data are expressed in renminbi (RMB) and converted to real terms based on the year 2000 prices.

3. Analysis of data and income convergence

3.1. Data analysis

The overall income growth patterns of Mainland China, Hong Kong and Macao in the postreform period of Mainland China are shown in Table 1. Mainland China has experienced relatively high growth since the beginning of economic reforms, and particularly so in recent

Table 1. Per capita RGDP of Mainland China, Hong Kong and Macao and their RGDP growth rates.

Year	Mainland China		Hong Kong		Macao	
	RGDP per capita	RGDP growth (%)	RGDP per capita	RGDP growth (%)	RGDP per capita	RGDP growth (%)
1982	1709.91	7.40	98378.16	7.95	86318.49	<i>n.a.</i>
1985	2381.13	11.90	114697.19	4.33	91211.71	-1.31
1990	3219.16	2.32	163716.41	7.10	117616.80	4.80
1995	5418.55	9.74	219088.69	2.03	128052.40	0.14
2000	7828.01	7.58	209914.57	-4.48	116769.40	4.17
2001	8419.02	7.55	204122.91	-2.76	117934.20	1.00
2002	9126.09	8.40	196696.49	-3.64	128306.30	8.79
2003	9978.57	9.34	184250.13	-6.33	1448650.00	12.91
2004	10922.08	9.46	176724.95	-4.08	179573.30	23.96
2005	11987.16	9.75	175645.67	-0.61	183344.50	2.10
2006	13247.62	10.52	173996.58	-0.94	201649.00	9.98
Average for 1982–2006		8.88		2.75		3.77

years. Mainland China's average annual growth rate during the sample period is 8.88%, which is higher than that of Hong Kong and Macao by 6.13% and 5.11%, respectively. Despite enormous disparities in per capita income levels, not only does the reform-led economic development of Mainland China bring about an income growth rate for the economy that is higher than that of Hong Kong and Macao, but it also narrows income gaps between Mainland China and these Chinese economies.

To better understand the income growth process in the sample period, besides considering all Mainland Chinese provinces along with Hong Kong and Macao, we also divide Mainland Chinese provinces into four regions for further investigation. The first is the coastal region consisting of Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi and Hainan. The second is the central region which is composed of Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan. The third region contains the western provinces of Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. Lastly, Guangdong is identified separately because of its geographic proximity and tight economic linkages with the two SARs.

The log of per capita GDP for the national average, regional averages, Guangdong, Hong Kong and Macao is plotted and compared in Figure 1. The RGDPs of Mainland Chinese provinces generally exhibit an increasing trend. However, the regional average curves are found to be roughly parallel to one another; that is, the income gaps across regions are relatively constant with no signs for them to diminish in size over time.

Comparing across economies, however, there is a tendency for the income gaps between Mainland China and Hong Kong and between Mainland China and Macao to reduce in magnitude over time. Such tendency is not very evident in the 1980s because the growth rate of Mainland China, as measured by the slope of the national average curve, is not much higher than that of Hong Kong and Macao. However, the narrowing of income gaps becomes more prominent in the 1990s and beyond, as Mainland China experiences more rapid growth while Hong Kong suffers from an economic slump turning into the late 1990s. The income ratios calculated as the per capita RGDP of Mainland China divided by that of Hong Kong and Macao presented in Table 2 help to quantify the tendency of income

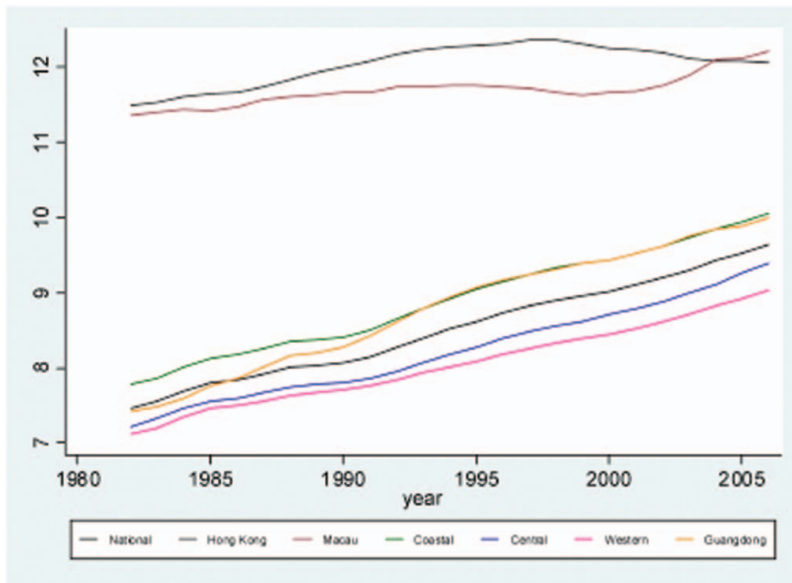


Figure 1. Log of per capita RGDP.

gap reduction among the Chinese economies over time. The income ratios with regard to Hong Kong and Macao are found to increase from 1.74% and 1.98% in 1982 to 7.61% and 6.57% in 2006, respectively. The implied rates of growth are 6.51% and 5.31% per annum for income ratios with reference to Hong Kong and Macao, respectively.

Table 2. Income ratios of Mainland China, Guangdong, Hong Kong and Macao, and per capita RGDP of Guangdong.

Year	Income ratios (%)		Guangdong RGDP per capita (RMB)	Income ratios (%)	
	Mainland China/Hong Kong	Mainland China/ Macao		Guangdong/ Hong Kong	Guangdong/ Macao
1982	1.74	1.98	1658	1.69	1.92
1985	2.08	2.61	2324	2.03	2.55
1990	1.97	2.74	3929	2.40	3.34
1995	2.47	4.23	8695	3.97	6.79
2000	3.73	6.70	12537	5.97	10.74
2001	4.12	7.14	13606	6.67	11.54
2002	4.64	7.11	15142	7.70	11.80
2003	5.42	6.89	17182	9.33	11.86
2004	6.18	6.08	18892	10.69	10.52
2005	6.82	6.54	19418	11.06	10.59
2006	7.61	6.57	21990	12.64	10.90
Average growth rate for 1982–2006	6.51	5.31		8.90	7.74

As for Guangdong, owing to its favorable geographical location and intimate economic contacts with Hong Kong and Macao, it is not surprising that its per capita income level is consistently higher than that at the national level from the mid-1980s. In addition, it is growing at a high speed throughout the whole sample period. Thus, Guangdong is able to achieve a narrowing of income gaps with Hong Kong and Macao over time. Its income ratios with Hong Kong and Macao have grown from 1.69% and 1.92% in 1982 to 12.64% and 10.90% in 2006, respectively. The implied growth paces of income ratios are 8.90% and 7.74%, respectively, which far exceed those of the national aggregate.

In general, it can be observed that the initially poorer Mainland Chinese provinces have been able to grow faster than the initially richer Hong Kong and Macao economies. If convergence is to be interpreted as the finding of such an inverse relationship between the initial per capita income levels and their growth rates in accordance with the cross-sectional notion, it appears that there is relatively strong indication of overall convergence among these Chinese economies. However, this sort of interpretation based on the cross-sectional approach may be erroneous as mentioned in Section 1. We therefore proceed to investigate the time-series properties of the data to better evaluate the income convergence issue among Mainland China, Hong Kong and Macao.

3.2. Income convergence analysis

We begin our analysis with a graphical inspection of the log of relative per capita incomes. Figure 2 depicts the time series for all Mainland Chinese provinces only. There are no signs of the narrowing of cross-economy income differences, as neither provinces with initial incomes below the group average generally exhibit positive growth in their relative incomes over time, nor provinces having initial incomes above the group average display negative growth in their relative incomes in general. In contrast, Figure 3, which includes Hong Kong and Macao along with all Mainland Chinese provinces, clearly exhibits a tendency for the

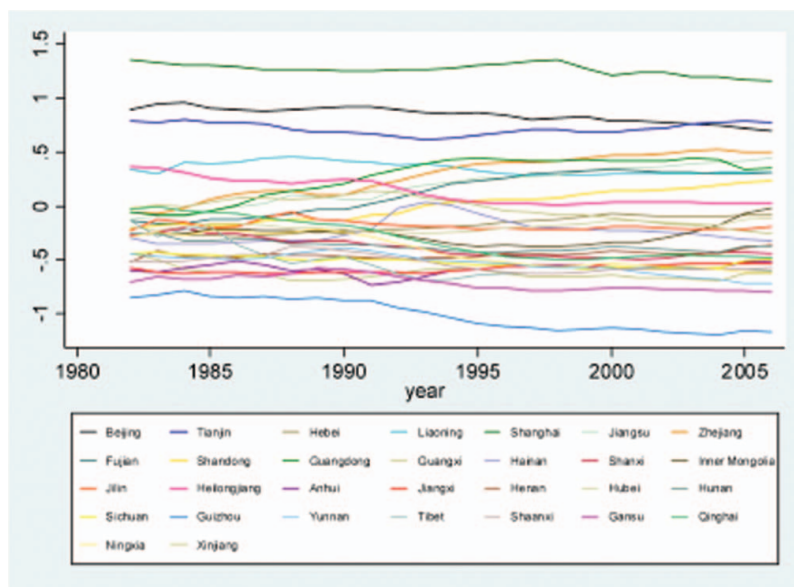


Figure 2. Log of relative per capita RGDP of Mainland China.

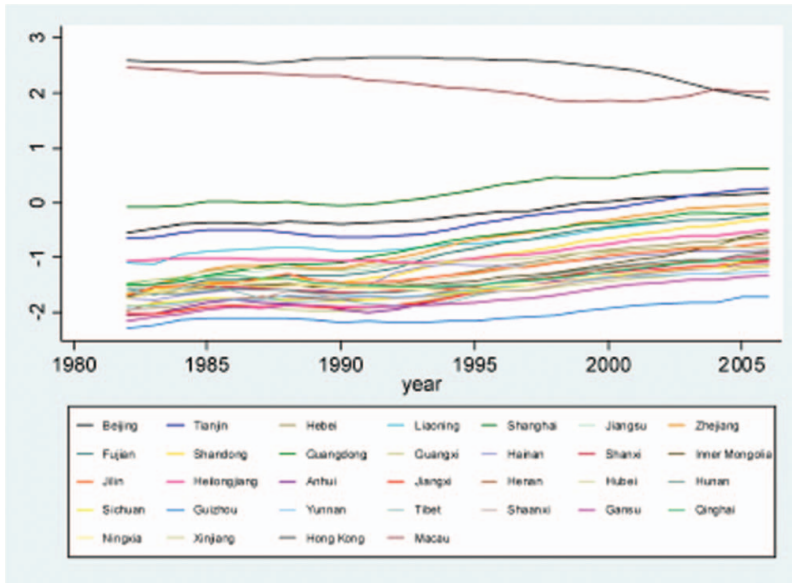


Figure 3. Log of relative per capita RGDP of Mainland China, Hong Kong and Macao.

series to close in on one another, that is, a narrowing of cross-economy income differentials over time, especially in the 1990s and beyond. On the one hand, Mainland Chinese provinces typically start off with initial incomes below average but with their relative incomes growing positively over time in general. On the other, Hong Kong and Macao, with initial incomes above average, exhibit negative growth in their relative incomes. It can also be noticed from both figures that the series tend to move together over time, which indicates the potential presence of cross-sectional dependence in our data.

Figures 4–7 show the log of relative per capita incomes of Mainland China at different regional levels and of Hong Kong and Macao. Comparing these graphs, we find that the patterns exhibited in Figures 4 and 7, which include the coastal provinces and the Guangdong Province, respectively, are quite different from those observed in Figures 5 and 6, which contain the central and western provinces, respectively. Relative incomes of the coastal provinces and Guangdong have grown faster than those of the central and western provinces so that relative income deviations of the former provinces from Hong Kong and Macao have gotten much smaller over time than those of the latter provinces.

Overall, in the multieconomy context, Mainland Chinese provinces having incomes initially below their equilibrium differentials exhibit faster growth than Hong Kong and Macao with initial incomes above their equilibrium differentials. However, for convergence to be realized under the present time-series framework, stationarity of the relative incomes of these economies, or stochastic convergence among these economies, is also required.

In applying the panel unit root tests to the data for the testing of stochastic convergence, two main cases are considered. The first is a benchmark case in which only Mainland Chinese provinces are analyzed. The second case investigates Mainland Chinese provinces together with Hong Kong and Macao. Since all the panel unit root tests employed rest on the assumption of cross-sectional independence, the individual ADF regressions in Equation (4) are estimated, and the resulting income residuals are tested for this assumption, using the cross-sectional dependence (CD) test advanced by Pesaran (2004). Table 3 shows the

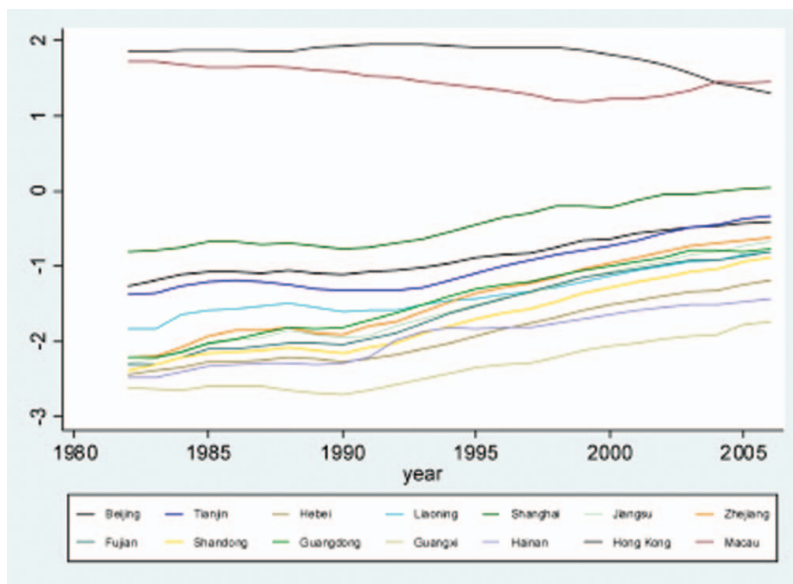


Figure 4. Log of relative per capita RGDP of the coastal region, Hong Kong and Macao.

CD test statistics for all cases, and the null hypothesis that the income residuals are cross-sectionally independent can be rejected at the 5% level or higher except in one scenario.

In the presence of cross-sectional dependence, the distributions of the panel tests depend on nuisance parameters and are unknown. The empirical distributions of these tests are thus simulated using the bootstrap method as in MW. It can also be noted that, in finite samples,

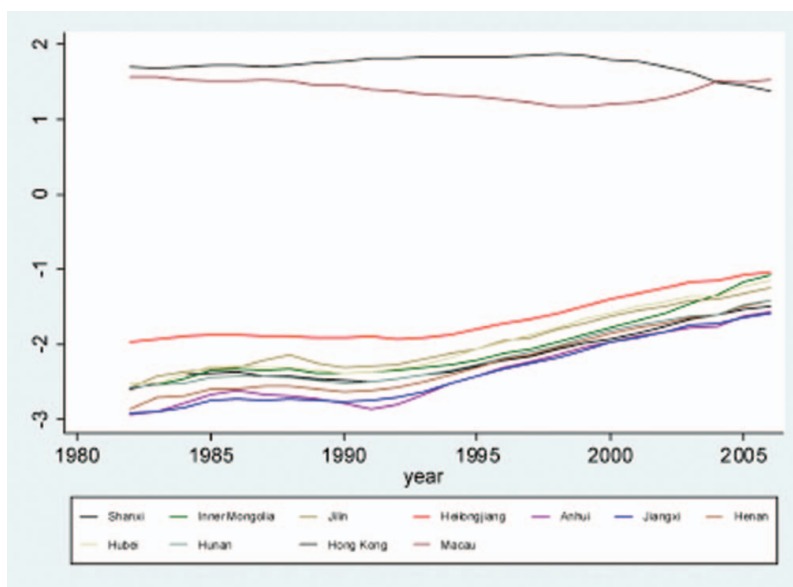


Figure 5. Log of relative per capita RGDP of the central region, Hong Kong and Macao.

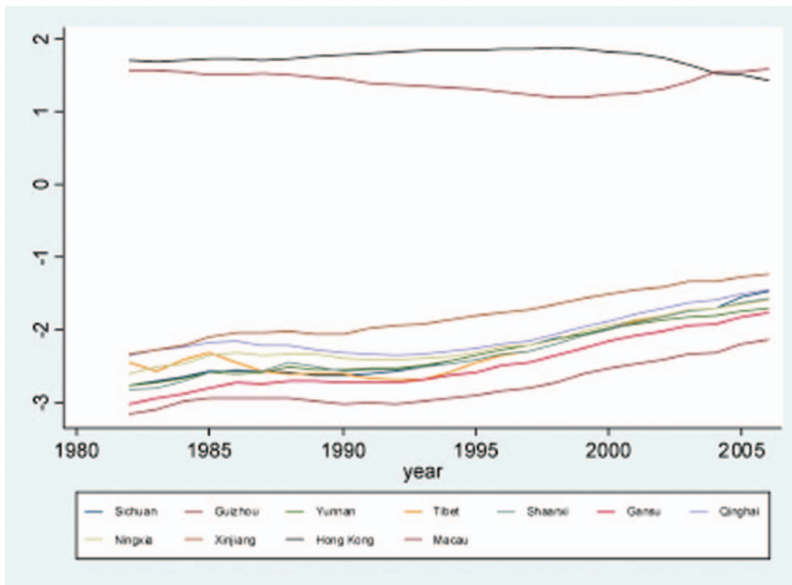


Figure 6. Log of relative per capita RGDP of the western region, Hong Kong and Macao.

the ADF test statistics depend on the time span and lag order used in each individual ADF regression. Thus, the finite sample mean and variance adjustment terms used to compute the IPS test and the finite sample ADF distributions from which p -values are obtained for the MW test are simulated as well. In implementing the tests, the lag order k_i in the

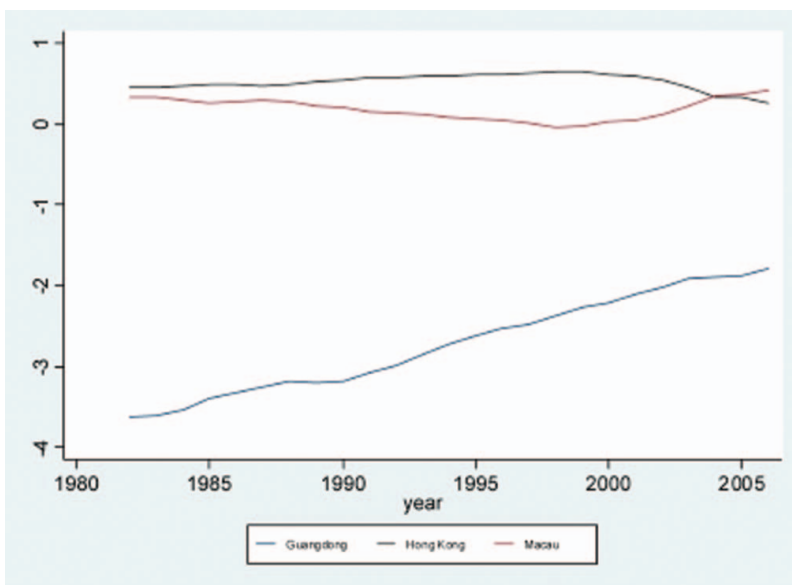


Figure 7. Log of relative per capita RGDP of Guangdong, Hong Kong and Macao.

Table 3. Cross-sectional dependence test results for ADF regression residuals.

	Mainland China		Mainland China, Hong Kong and Macao	
	CD statistic	<i>p</i> -value	CD statistic	<i>p</i> -value
National	2.185	.014	30.390	.000
Costal	−0.592	.277	13.431	.000
Central	−1.823	.034	12.204	.000
Western	−1.976	.024	11.799	.000
Guangdong	—	—	−2.735	.003

ADF regression for each cross section is determined by the general-to-specific *t*-sig method starting with an upper bound of four lags.

The test results are set out in Tables 4 and 5. First consider those for Mainland China only, which are presented in Table 4. No tests are found to reject the unit root null hypothesis at the national level. At the regional level, only the MW test rejects the unit root null at the 10% level for the western region, and no rejection can be obtained for the coastal and central regions. Therefore, the test results generally do not provide evidence for the stationarity of income disparities across provinces, thus suggesting that Mainland Chinese provinces do not stochastically converge.

Next consider the case in which Mainland China is analyzed together with both Hong Kong and Macao. From the test results summarized in Table 5, we find no evidence for stochastic convergence with all tests, regarding the case of Guangdong, Hong Kong and Macao. As for the coastal and western regions, the null of nonstationarity can be rejected at the 10% level, using, respectively, the MW and LLC tests. Thus, there is weak evidence to support stochastic convergence at these two regional levels. However, it is notable that all the tests provide evidence for stochastic convergence not only among western provinces, Hong Kong and Macao but also among all Mainland Chinese provinces and the two SARs, as the unit root null can be rejected at the 5% level or higher, using all three panel tests.

Taken together, the results give an interesting picture for the convergence pattern among Mainland Chinese provinces and the two SARs. Although there is little evidence to support the notion of income convergence within Mainland China at all levels, per capita incomes among Mainland Chinese provinces and the two SARs appear to be converging at the national level, in spite of mixed results obtained at different regional levels.

Table 4. Panel unit root test results for Mainland China.

	LLC		IPS		MW	
	Statistic	<i>p</i> -value	Statistic	<i>p</i> -value	Statistic	<i>p</i> -value
National	−1.462	.682	0.128	.750	63.277	.855
Costal	−2.360	.240	−1.451	.239	31.700	.434
Central	−0.777	.630	−1.775	.227	33.251	.190
Western	−2.785	.138	−1.989	.153	40.545	.051

Table 5. Panel unit root test results for Mainland China, Hong Kong and Macao.

	LLC		IPS		MW	
	Statistic	<i>p</i> -value	Statistic	<i>p</i> -value	Statistic	<i>p</i> -value
National	−6.032	.079	−3.889	.069	129.705	.046
Costal	−3.660	.145	−2.489	.112	56.144	.079
Central	−3.578	.079	−0.760	.246	36.565	.175
Western	−5.162	.022	−2.635	.066	43.163	.089
Guangdong	3.154	.950	0.183	.492	4.361	.617

4. Discussion

Considering Mainland Chinese provinces only, the general findings of pervasive divergence both nationally and within regions are consistent with those drawn in the literature, such as Yao and Zhang (2001), Zhang *et al.* (2001) and Pedroni and Yao (2006). Amid rapid growth of the economy, provincial income disparities have been widening because of differences in provincial conditions, with the western region as the only possible exception. The similarity of endowments possessed by and the unfavorable geographical factor faced by these western provinces have given rise to some evidence for income convergence among them.

In contrast, the incomes of Mainland Chinese provinces as a whole are found to be converging with those of Hong Kong and Macao in the long run. This can be realized through the interplay of two forces at work. First, Macao's income level is lower than that of Hong Kong and relatively closer to those of Mainland Chinese provinces, for most of the sampling years. It is therefore easier for Mainland Chinese provinces to achieve income convergence with Macao when the Mainland Chinese economy has been expanding continuously its exports to the US and has thereby been speeding up the overall growth of the economy. Thus, there is a tendency of income convergence between Mainland China and Macao. Second, the liberalization of the gaming industry in Macao has brought about a large influx of FDI and a substantial upsurge in tourist arrivals, which have contributed to the acceleration of the growth pace of the territory. In the meantime, the outbreak of the severe acute respiratory syndrome (SARS) in Hong Kong in 2003 has seriously and adversely affected the economic performance of the territory. Consequently, the per capita RGDP of Macao has been growing rapidly to catch up with that of Hong Kong. On the whole, Macao can be regarded as a catalyst in the process of income convergence among Mainland Chinese provinces, Hong Kong and Macao.

The scenario of Guangdong, Hong Kong and Macao also warrants some discussion. There have been tight economic linkages among Guangdong, Hong Kong and Macao since the economic reforms of Mainland China. For instance, of the total amount of actually used FDI from Hong Kong–Macao to Mainland China, 31% is utilized in Guangdong. Also, of the total amount of exports from Mainland China to Hong Kong–Macao, 69% was exported by Guangdong, and 50% of the total Mainland Chinese imports from Hong Kong–Macao was purchased by Guangdong.³ Despite the well-developed economic linkages, our test results do not indicate any evidence of income convergence among them. One plausible explanation for the finding of no convergence is that Guangdong has followed a development path with high growth potential that is different from those taken by Hong Kong and Macao. As indicated in Huang and Sharif (2009, p. 814), 'the productivity gains in Guangdong domestic firms result largely from their own commitment to R&D investment and innovation efforts' with limited impact of spillover effects from inward FDI funded by investors from Hong Kong, Macao and Taiwan. Furthermore, as exhibited in Qian and Smyth (2006, p. 35), the

economic growth of Mainland Chinese provinces, including Guangdong, 'depends heavily on the accumulation of physical capital stock', which could explain 55% of the growth. Given the stronger investment incentive as demonstrated by the highest gross fixed capital formation to GDP ratio, at an average of 30.41% per annum for the period of 1997–2007 versus 24.45% and 19.66% for Hong Kong and Macao, respectively, Guangdong tends to have stronger growth than Hong Kong and Macao. Besides, the possible high-growth development path of Guangdong may also be evidenced by the fact that while Guangdong's per capita RGDP was growing at 11.47% per annum between 1982 and 2006, those of Hong Kong and Macao were only growing at 2.75% and 3.77%, respectively.

Our study is different from that of Lei and Yao (2008) in the following aspects. First, the sample period used in this paper is an extension of that used in Lei and Yao (2008), which covers a period of rapid growth for Mainland China and therefore allows its provinces to narrow their income gaps with Hong Kong and Macao to achieve income convergence. Second, instead of modeling on bilateral income ratios as in Lei and Yao (2008), this paper adopts the multieconomy model of Carlino and Mills (1993). Stationarity is thus tested for the per capita incomes of individuals relative to the group average, rather than the relative bilateral incomes of individuals. Third, in contrast to Lei and Yao (2008), this paper employs the panel unit root tests instead of the univariate unit root tests in hypothesis testing. The former tests are more powerful than their latter counterparts, and the inference drawn tends to be more reliable.

The finding of income convergence among Mainland China, Hong Kong and Macao implies tremendous success of the economic reforms of Mainland China. It has allowed the inhabitants of Mainland China to steadily improve their living standards with an increasing income level to gradually transform themselves into a high-income class. Continuous shrinking of the income gap and the subsequent achievement of income convergence in the long run helps to strengthen the social stability of the economy. Furthermore, the implied sustainable economic growth on the Mainland side would further improve the purchasing power of the inhabitants, which may bring about an expansion of imports from the SARs, leading to a higher level of economic integration among them. Finally, the growing economic strength of Mainland China can also be regarded as one of the irreversible economic forces to push forward economic integration and even political unification between the two sides of the Straits.

Despite the finding of long-run convergence, existing income gaps among Mainland Chinese provinces, Hong Kong and Macao are still enormous. The Mainland Chinese Government may need to adopt policies to accelerate the speed of convergence among these Chinese economies. In addition, we should be cautious that the conclusion on income convergence is only valid for the national level among all Mainland Chinese provinces, along with Hong Kong and Macao. At the individual provincial level, income convergence may not be the long-run scenario, and Guangdong's case can be used as an illustration. The province's per capita income tends to diverge from those of Hong Kong and Macao. It is likely that the other fast-growing provinces or municipalities, such as Beijing, Tianjin and Shanghai, may also fail to achieve income convergence with Hong Kong and Macao individually, despite the finding of income convergence when taking into account all Mainland Chinese provinces simultaneously. For this reason, the fulfillment of overall income convergence cannot rule out the possibility that Hong Kong and Macao may be surpassed, in terms of per capita income, economic strength and even economic role in the country, by a number of fast-growing Mainland Chinese provinces. This implies that the two SARs are required to adopt more aggressive policies to deepen their economic cooperation and integration with Mainland China so as to avoid being dwarfed by these Mainland Chinese provinces.

5. Conclusion and policy suggestions

This paper has addressed the issue of income convergence among Mainland China, Hong Kong and Macao in the postreform period of Mainland China by adopting the multieconomy income convergence model and employing the panel unit root testing techniques. Unlike previous investigation, this paper has found that relative incomes of Mainland China, Hong Kong and Macao have no tendency to deviate from one another in the long run. The occurrence of income convergence among these Chinese economies can be attributed to rapid income growth on the Mainland China and Macao sides but relatively sluggish economic performance of Hong Kong in recent years, which have made income convergence possible. In this long-run income convergence process, Macao can be regarded as playing a catalytic role.

Since the beginning of the economic reforms of Mainland China, businessmen from Hong Kong and Macao have been carrying out intensive trade with, and making substantial investment in, the coastal region. Such kinds of economic contacts between the central and western regions and the two SARs remain relatively underdeveloped. The empirical evidence for income convergence among Mainland China, Hong Kong and Macao as a whole suggests promising prospects for deepening economic cooperation and integration among these Chinese economies. In the long-run income convergence process, the potential of establishing closer economic linkages between the SARs and the central and western regions may be explored and formulated. Building on the decade-long infrastructure development in the poor provinces as launched in the 'Western Region Development', policy-makers may devise strategies to further extend its existing 'software' components, namely preferential policies on human resources development, tax incentives, investment environment and FDI attractions. More dynamically, policy-makers may motivate businessmen from Hong Kong, Macao and the Coastal region by providing incentives, such as subsidies to certain targeted industries, to relocate their low value-added and labor-intensive manufacturing industries from the high-cost and congested coastal region to the central and western parts of the country. Through the use of incentive policies, coupled with the improved hardware and software facilities, the investment environment of the central and western regions may be made more conducive so as to attract FDI, not only from Hong Kong, Macao and the coastal region but also from the rest of the world.

In the course of deepening economic cooperation and integration among the Chinese economies, the central and western regions may be developed into new production bases for labor-intensive manufacturing products. The coastal region may then be restructured to focus on high-value-added manufacturing and the development of the service sector. By strengthening its role as a regional financial and fund-raising center through measures such as securing a greater involvement in RMB transaction, Hong Kong may serve as a coordinator of outward direct investment financed by investors from Mainland China. With industrial diversification, Macao may be envisaged to become a center for meetings, incentives, conventions and exhibitions in the Greater China region. Through the exploitation of their comparative advantages in economic cooperation and integration, mutual benefits for the Chinese economies may be derived, thereby promoting better economic equity for the entire country and leading to sustainable economic growth in the long run for China as a whole.

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Notes

1. These figures are taken from various issues of the *China Statistical Yearbook*.
2. This generalizes the ARMA (2,0) process used in Carlino and Mills (1993).
3. These figures are based on the 2006 data from the *China Statistical Yearbook*.

References

- Barro, R., 1991. Economic growth in a cross-section of countries. *Quarterly journal of economics*, 106, 407–443.
- Barro, R. and Sala-i-Martin, X., 1992. Convergence. *Journal of political economy*, 100 (2), 223–251.
- Bernard, A.B. and Durlauf, S.N., 1996. Interpreting tests of the convergence hypothesis. *Journal of econometrics*, 71, 161–173.
- Carlino, G.A. and Mills, L.O., 1993. Are U.S. regional incomes converging? *Journal of monetary economics*, 32, 335–346.
- Chen, J. and Fleisher, B.M., 1996. Regional income inequality and economic growth in China. *Journal of comparative economics*, 22, 141–164.
- Cheung, Y.W., Chinn, M.D., and Fujii, E., 2007. *The economic integration of greater China: real and financial linkages and the prospects for currency union*. Pokfulam, Hong Kong: Hong Kong University Press.
- Dawson, J.W. and Sen, A., 2007. New evidence on the convergence of international income from a group of 29 countries. *Empirical economics*, 33, 199–230.
- Démurger, S., 2001. Infrastructure development and economic growth: an explanation for regional disparities in China? *Journal of comparative economics*, 29, 95–117.
- Durlauf, S.N. and Johnson, P.A., 1995. Multiple regimes and cross-country growth behaviour. *Journal of applied econometrics*, 10, 365–384.
- Galvão, A.F., Jr. and Reis Gomes, F.A., 2007. Convergence or divergence in Latin America? A time series analysis. *Applied economics*, 39, 1353–1360.
- Gundlach, E., 1997. Regional convergence of output per worker in China: a neoclassical interpretation. *Asian economic journal*, 11 (4), 423–442.
- Hong Kong SAR Government, 1967–2007. *Hong Kong monthly digest of statistics*. Wan Chai, Hong Kong: Census and Statistics Department, The Hong Kong SAR Government. Available from: <http://www.info.gov.hk/censtatd/eng/hkstat/index.html> [Accessed 15 May 2008].
- Huang, C. and Sharif, N., 2009. Manufacturing dynamics and spillovers: the case of Guangdong province and Hong Kong, Macau and Taiwan (HKMT). *Research policy*, 38, 813–828.
- Im, K.S., Pesaran, M.H., and Shin, Y., 2003. Testing for unit roots in heterogeneous panels. *Journal of econometrics*, 115, 53–74.
- Jian, T., Sachs, J.D., and Warner, A.M., 1996. Trends in regional inequality in China. *China economic review*, 7 (1), 1–21.
- Lei, C.K. and Yao, S., 2008. On income convergence among China, Hong Kong and Macao. *The world economy*, 31, 345–366.
- Levin, A., Lin, C.F., and Chu, C.S.J., 2002. Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics*, 108, 1–24.
- Li, Q. and Papell, D., 1999. Convergence of international output: time series evidence for 16 OECD countries. *International review of economics and finance*, 8, 267–280.
- Lowey, M.B. and Papell, D.H., 1996. Are U.S. regional incomes converging? Some further evidence. *Journal of monetary economics*, 38, 587–598.
- Maasoumi, E. and Wang, L., 2008. Economic reform, growth and convergence in China. *Econometrics journal*, 11, 128–154.
- Macao SAR Government, 1982–2007. *Yearbook of statistics of Macao*, various issues. Macao: Statistics and Census Services, Macao SAR government. Available from: <http://www.dsec.gov.mo> [Accessed 15 May 2008].
- Maddala, G.S. and Wu, S., 1999. A comparative study of unit root tests with panel data and a new simple test. *Oxford bulletin of economics and statistics*, 61, 631–652.
- Mankiw, N.G., Romer, D., and Weil, D.N., 1992. A contribution to the empirics of economic growth. *Quarterly journal of economics*, 107, 407–437.
- National Bureau of Statistics of China, 1980–2007. *China statistical yearbook*, various issues. Beijing: China Statistics Press.

- Pedroni, P. and Yao, J.Y., 2006. Regional income divergence in China. *Journal of Asian economics*, 17, 294–315.
- Pesaran, M.H., 2004. *General diagnostic tests for cross section dependence in panels*. Cambridge: Faculty of Economics, University of Cambridge, Cambridge working paper in economics 0435.
- Qian, X. and Smyth, R., 2006. Growth accounting for the Chinese provinces 1990–2000: incorporating human capital accumulation. *Journal of Chinese economic and business studies*, 4 (1), 21–37.
- Quah, D., 1993. Galton's fallacy and tests of the convergence hypothesis. *Scandinavian journal of economics*, 95, 427–443.
- Raiser, M., 1998. Subsidizing inequality: economic reforms, fiscal transfers and convergence across Chinese provinces. *Journal of development studies*, 34 (3), 1–26.
- Sakamoto, H. and Islam, N., 2008. Convergence across Chinese provinces: an analysis using Markov transition matrix. *China economic review*, 19, 66–79.
- Sung, Y.-W., 2005. *The emergence of greater China: the economic integration of Mainland China, Taiwan and Hong Kong*. Basingstoke and New York: Palgrave Macmillan.
- Tomljanovich, M. and Vogelsang, T.J., 2002. Are U.S. regions converging? Using new econometric methods to examine old issues. *Empirical economics*, 27, 49–62.
- Weeks, M. and Yao, J.Y., 2003. Provincial conditional income convergence in China 1953–1997: a panel data approach. *Econometric reviews*, 22, 59–77.
- Yao, S. and Zhang, Z., 2001. On regional inequality and diverging clubs: a case study of contemporary China. *Journal of comparative economics*, 29, 466–484.
- Zhang, Z., Liu A., and Yao, S., 2001. Convergence of China's regional incomes 1952–1997. *China economic review*, 12, 243–258.