The World Economy (2008)
doi: 10.1111/j.1467-9701.2007.01072.x

On Income Convergence among China, Hong Kong and Macau

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1. INTRODUCTION

BEFORE economic reforms, China advocated a socialist central planning system to guide its economic development under which almost all economic decisions were centralised and manipulated by the authorities. On the contrary, Hong Kong and Macau adopted a free market system. Owing to the differences in economic systems and development strategies, in endowments of physical and human capital, reinforced by frequent occurrences of natural disasters and political struggles, China became one of the world's poorest nations while Hong Kong and Macau joined the rank of high-income economies. By 1978, per capita GDP in China was only a tiny fraction of the level achieved in Hong Kong and Macau.[1]

Since economic reforms in 1978, however, revolutionary changes have taken place in China as the country transforms its economy from a centrally-planned to a market-oriented system. Economic transition and liberalisation have reduced the ideological differences between China, Hong Kong and Macau, and market mechanism has eventually become the underlying driving force for all.

Thanks to China's fast economic growth, its income gaps with Hong Kong and Macau have been gradually reduced since economic reforms. This study aims to quantify the pace and identify the key determinants of income convergence. China is a large country and regional economic development has been uneven. It is likely that some regions may have been converging with Hong Kong and Macau, but others may have not. Even if all regions were catching up, the space of convergence would have been different among regions. As a result, it is important to examine if China as a whole or only some provinces is converging with Hong Kong and Macau and to examine the different patterns and extents of

The authors thank two anonymous referees and the editor, Professor David Greenaway, for their valuable comments, but remain solely responsible for any errors or omissions herein.

[1] In this paper, China refers to mainland China. SARs refer to Hong Kong and Macau, which are two special administrative regions of China. Greater China includes China and its two SARs.

convergence among the Chinese regions. Moreover, it is hypothesised that openness is an important factor contributing to the process of income convergence.

Many articles have discussed regional disparities and growth differences in China from different perspectives, among which are Jian et al. (1996), Tsui (1996), Gundlach (1997), Raiser (1998), Yao (1999), Demurger (2001), Yao and Zhang (2001a and 2001b) and Zhang (2001). However, almost all of these studies have placed their emphasis on China. For some reason, the issues of income disparities and convergence between China, Hong Kong and Macau, have been overlooked. In contrast, this study not only focuses on China, but also Hong Kong and Macau to investigate the situations on growth differential and income disparities, with an intention to assess if the income levels of these economies are converging, and if yes, how.

The rest of this paper is organised as follows. Section 2 presents a literature review and research methodology. Section 3 uses a non-parametric approach to describe the evolution of income convergence. Section 4 employs an augmented Solow growth model and a unit root test to find evidence of δ-, β-, and stochastic convergence, and to examine the effects of investment, population and openness on income convergence among the Chinese provinces, Hong Kong and Macau. Section 5 concludes.

2. LITERATURE REVIEW AND METHODOLOGY

The concept of income convergence is derived from the neoclassical growth model. The phenomenon is built based on the assumptions of diminishing returns on capital, common preferences and technology. Two concepts of convergence were discussed in the papers of Barro and Sala-i-Martin (1990 and 1992), Sala-i-Martin (1994), Bernard and Durlauf (1996) and Raiser (1998), etc. The first is β-convergence which describes an inverse relationship between initial income levels and growth. If an initially poorer economy grows faster than an initially richer one, there is β-convergence. The other is δ-convergence, which focuses on the actual income inequality among regions or countries. If income inequality declines, the concerned regions or economies achieve δ-convergence. It is worth noting that β-convergence is a necessary but not sufficient condition for δ-convergence, or that δ-convergence includes β-convergence, but not vice versa.

The theoretical underpinning of economic growth and income convergence is related to the linkage between openness and economic growth. The hypothesis that openness can lead to better economic performance and contribute to the process of income convergence between the poor and rich economies is supported by the new growth theory. Strong empirical evidence is found in Edwards (1993) who conducts a comprehensive literature review and concludes that growth is positively related to openness and trade liberalisation in many developing

countries. A similar conclusion is drawn in Greenaway and Sapsford (1994) and Greenaway et al. (2002).

a. β-Convergence

On absolute or unconditional β-convergence, Baumol (1986) estimates the growth rate of per capita GDP against its initial level and draws a conclusion favouring unconditional cross-country income convergence in 16 OECD countries. Barro (1991 and 1994) shows that unconditional income convergence with respect to both personal income and gross state product appeared in the United States during 1880–1988. The dispersion of personal income declined in the period which could be viewed as evidence of δ-convergence. In Europe, both β- and δ-convergences were observed among 74 regions of seven countries for the period 1950–85, at a rate of approximately 2 per cent per year. The analysis also discovers that the rate of β-convergence could vary over time, depending on technology, preferences, labour and capital mobility.

In Mankiw et al. (1992), the role of secondary- and primary-school enrolment rate was systematically discussed. The authors introduce an augmented Solow growth model (MRW) as shown in equation (1), taking human-capital accumulation into consideration, with an attempt to explain the difference in international income levels:[2]

$$\ln y_t = \ln A_0 + gt - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n + g + \delta) + \frac{\alpha}{1 - \alpha - \beta} \ln s_k + \frac{\beta}{1 - \alpha - \beta} \ln s_h, \quad (1)$$

where y_t is income per capita, n and g growth rates of labour and technology, δ depreciation rate of physical capital, s_k saving rate, and s_h human capital, α and β capital and labour shares of output and their sum is assumed to be less than 1.

Incorporating the steady-state income level y^*, the speed of convergence was defined as:

$$\frac{d \ln y_t}{dt} = \lambda[\ln y^* - \ln y_t], \quad (2)$$

where $\lambda = (n + g + \delta)/(1 - \alpha - \beta)$ and implying that:

$$\ln y_t = (1 - e^{-\lambda t}) \ln(y^*) + e^{-\lambda t} \ln y_0,$$

then the growth function could be written as:[3]

[2] Mankiw et al. (1992, p. 417).
[3] Mankiw et al. (1992, p. 423).

$$\ln y_t - \ln y_0 = (1 - e^{-\lambda t}) \frac{\alpha}{1-\alpha-\beta} \ln s_k + (1 - e^{-\lambda t}) \frac{\beta}{1-\alpha-\beta} \ln s_h - (1 - e^{-\lambda t}) \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n + g + \delta) - (1 - e^{-\lambda t}) \ln y_0, \quad (3)$$

where y_0 is income per capita in the initial period.

The augmented model predicts that the income levels of countries with similar technologies, investment rate and population growth tend to converge, at a rate slower than the one prevailing in the typical Solow model. Investment, population growth and human-capital investment rates have improved the goodness-of-fit of the estimations and lowered the estimated coefficient of the initial income level. Without the additional control variables, however, the income levels of the sampling economies have failed to converge unconditionally, except for the OECD members.

In the case of China, Lardy (1980) is one of the earliest studies to review the condition of income distribution and suggests that:

> the degree of interregional income inequality in China substantially exceeds the inequality found in several countries that are treated in the economic development literature as classic cases of north-south dualism.

Lyons (1991) reviews the overall development of China, and the issue of inter-provincial income disparities during 1952–87. Making use of net material product and provincial private consumption, the standard deviation and coefficient of variation reveal considerable disparity in the pre-reform period, especially in the 1950s. However, since economic reforms, the argument of widening income gaps across provinces could be rejected.

Chen and Fleisher (1996) assess post-reform income inequality in China. They use the MRW human capital augmented Solow model to find evidence supporting income convergence during 1952–65 but divergence during 1965–78. Strong evidence of convergence was found during the reform period due to rural reforms. Since the late 1980s, however, income inequality rose between the coastal and inland regions. Intra-regional disparities declined during the reform period but inter-regional income gaps experienced little improvement. FDI to GDP ratio was found to be strongly significant and has contributed to accelerating the pace of conditional convergence. In another study, Gundlach (1997) suggests an inter-provincial income convergence rate of 2.2 per cent in China. The empirical estimations have also indicated that 'convergence of output per worker across Chinese provinces has been supported by high inter-provincial physical capital mobility'.[4] This rate was expected to decline as economic reforms encouraged

[4] Gundlach (1997, p. 425).

fiscal decentralisation, and might thus hinder inter-provincial capital mobility. This is raised by Raiser (1998), who found a reduced pace of income convergence after 1985. This finding was attributed to the shift of rural to industrial reforms, as well as the system of fiscal transfers in the post-reform period. The former transition allowed the relatively richer coastal provinces to benefit disproportionately and thus slowed down the convergence process. The latter system, which has provided fiscal aids to the relatively richer inland provinces, became a serious obstacle to income convergence among the inland provinces.

Yao and Zhang (2001a) study the income inequality problem of China, focusing on the issue of 'Club Divergence', which was a result of income divergence between three large geo-economic regions: East, Central and West. Investment to GDP ratio, population growth, technological progress, depreciation, export to GDP ratio and two dummies for the distance between the East to Central and Central to West are considered as key explanatory variables. The hypothesis of 'Club Divergence' is proved given the negative and significant estimated coefficients for two distance dummies. It implied that the further away from the growth centre in the East, the slower would be the rate of economic growth. Besides, a unit root test is performed to test for stochastic convergence and the result suggests 'Club Divergence' as the East and the West are found to 'belong to two different clubs'.[5] In Yao and Zhang (2001b), the panel data approach is employed to examine the convergence issue of China across different provinces and regions. They adopt the MRW human-capital augmented Solow growth model as the specification and introduce trade to GDP ratio and length of highways, railways and waterways as additional explanatory factors. The estimation results suggest δ-divergence and absolute β-divergence during 1978–95 when club dummies are controlled. The results also indicate conditional β-convergence after controlling for population growth, depreciation, physical and human capital investment, trade and transportation. It is found that the three geographical regions of China, namely the coastal, central and western regions, might have converged into 'three distinctive geo-economic clubs of economic growth, within each economic club, there was a tendency of convergence, but between the clubs, there was a tendency of divergence'.[6]

Apart from applying the cross-sectional and pooled data analyses, the panel unit root test is employed by Yao et al. (2000) in testing the evidence of income convergence of China at the provincial level. The ADF approach similar to Ben-David (1997 and 2001) and Karras (1997) was followed to test if the deviation from the sample mean with respect to real GDP per capita of a Chinese province inherited any unit root. In the pre-reform period 1952–77, the unit root null hypothesis is rejected, implying that the Chinese provinces achieved income

[5] Yao and Zhang (2001a, p. 480).
[6] Yao and Zhang (2001b, p. 182).

convergence. In the post-reform period, a unit root is found, showing evidence of regional income divergence during 1978–97. In addition, the authors suggest that 'China's regional income has embarked on a divergence course and formed a divergence club since 1978'.[7]

In examining the convergence issue of China, Hong Kong and Macau, this paper adopts the model suggested in Baumol (1986) and applied in Chen and Fleisher (1996), Jian et al. (1996), Gundlach (1997), Raiser (1998) and Yao and Zhang (2001a) to regress the growth rate of real GDP per capita against its initial level using both cross-sectional and panel data. The regression function is specified in equation (4):[8]

$$\ln y_{it} - \ln y_{i0} = \alpha + \beta \ln y_{i0} + \varepsilon_{it}, \tag{4}$$

$$\text{with} \quad \beta = (1 - e^{\lambda t}),\ \lambda = \text{rate of convergence},$$

where y_{it} and y_{i0} are the end and initial levels of real GDP per capita. A statistically significant and negative β suggests unconditional income convergence. It implies that initially poor economies can achieve a higher growth rate so as to catch up with the initially rich regions. On the contrary, a positive β shows income divergence since an economy with higher initial income tends to grow faster than an initially poorer one, leading to more income inequality over time.

If unconditional β-convergence is observed, then conditional β-convergence is also implied. However, it is also possible to conduct a conditional convergence analysis to identify factors (e.g. investment, population growth and openness) that contribute to accelerating the pace of income convergence. Incorporating these additional factors, the estimation equation can be written as equation (5):

$$\ln y_{ti} - \ln y_{0i} = \gamma_0 + \gamma_1 \ln y_{0i} + \gamma_2 \ln(s)_i + \gamma_3 \ln(n + g + \delta)_i + \gamma_4 \ln(open)_i + \varepsilon_i. \tag{5}$$

This specification is developed from the MRW augmented Solow growth model with a Cobb-Douglas production as the basis. In addition to the initial per capita real GDP y_{0i}, growth-related factors such as investment ratio s_i (measured as investment to GDP), population growth rate n, rate of technological progress g, depreciation rate δ, and openness ratio $open_i$ (measured as trade to GDP ratio) are included in the specification.[9] λ is the speed of conditional convergence to be estimated and y_{ti} is real GDP per capita at time t.

[7] Yao et al. (2000, p. 13).
[8] Raiser (1998, p. 3).
[9] The rate of technological progress, g, and the rate of capital depreciation, δ, are unknown, but most empirical studies have used an artificial value of 5 per cent to represent the sum of these two values. This paper follows the same approach.

Furthermore, to test for stochastic convergence, the ADF test is conducted based on equation (6):

$$\Delta \ln(yr)_t = a_0 + a_1 t + a_2 \ln(yr)_{t-1} + \sum_{i=1}^{p} \beta_i \Delta \ln(yr)_{t-i} + \varepsilon_t, \tag{6}$$

where yr_t is the per capita income ratio of the Chinese provinces over Hong Kong. If the null hypothesis of having a unit root is rejected, as suggested in Zhang et al. (2001) and Yao and Zhang (2001b), the relative income series tends to follow a stationary process and all the shocks will only bring about temporary impacts. The relative income tends to return to its steady-state level in the long run, with a tendency to achieve stochastic convergence. In contrast, if the null hypothesis cannot be rejected, relative income may not converge to its steady state, and is regarded as diverging.

b. δ-Convergence

The issue of σ-convergence is studied to estimate the static disparities in per capita income levels. If income inequality is declining, there will be δ-convergence among the concerned economies. The coefficient of variation (CV), shown in equation (7), is a common measurement of income inequality:

$$CV = \frac{\sqrt{\dfrac{\sum (y_i - \bar{y})^2}{n}}}{\bar{y}}, \tag{7}$$

where y_i is real GDP per capita in region i and $\bar{y}$ is national mean value.

The higher the value of CV, the more inequality will be. If CV declines, there is evidence of δ-convergence. This approach has been widely used in the recent literature, such as Lyons (1991), Tsui (1993), Chen and Fleisher (1996), Raiser (1998), Chang (2002) and Zheng et al. (2000).

Lyons (1991) adopts both the weighted and unweighted (by population) CVs with different composition to estimate the inequality problem of China with respect to net material product per capita. The value of CV rose during 1957–60, but declined to its 1957 level by 1962. It rose again during 1967–77 and declined in the early years of economic reforms 1978–85. Tsui (1996) shows a similar pattern of reduced inequality during the early reform period but a rising inequality after 1985.

Chen and Fleisher (1996) show a rising CV in the pre-reform period with a downward drift only after 1980. However, there was a tendency for the CV to increase after 1990. The increase was attributed to the widening gap between the

coastal and non-coastal provinces. In Raiser (1998), the CV based on provincial GDP per capita show a declining trend over 1978–92 from 0.98 to 0.56. Afterwards, the Chinese provinces were divided into coastal and interior regions and a contraction was found in the coastal region, from 0.78 in 1978 to 0.35 in 1992. For the interior, its CV declines from 0.38 in 1978 to 0.28 in 1987, then increases again to 0.35 in 1992. A similar pattern is also found in Zheng et al. (2000).

3. NON-PARAMETRIC ANALYSIS ON INCOME CONVERGENCE

a. Income Inequality at National Level

Tables 1 and 2 compare real GDP growth and real GDP per capita of China, Hong Kong and Macau. Data for China are available from 1952 for half a century up to 2002. Data for Hong Kong are available only from 1962 and for Macau from 1982.

China enjoys a higher growth rate than Hong Kong or Macau in all the sub-periods except for 1973–82. Even in the pre-reform period, China was able to achieve an average rate of growth of 6.48 per cent during 1953–77, and a rate of 7.05 per cent was recorded from 1962 to 1977, higher than Hong Kong's growth rate of 6.24 per cent for the same period. In the reform period 1978–2002, China experienced a much higher rate of growth at 9.51 per cent per year, outperforming Hong Kong by 3.35 percentage points on an annual basis. Similarly, the growth performance of China also overshadows that of Macau. During 1983–92, the average real GDP growth rate of China was 10.26 per cent, outperforming Macau

TABLE 1
Real GDP Average Growth Rate in Comparison (Per cent)

Period	*China*	*Hong Kong*	*Macau*
1953–1962	4.36	n.a.	n.a.
1963–1972	9.35	5.35	n.a.
1973–1982	6.63	10.49	n.a.
1983–1992	10.26	8.04	7.80
1993–2002	9.37	1.28	2.08
1953–1977	6.48	6.24[a]	n.a.
1978–2002	9.51	6.16	4.94[b]

Notes:
Real GDP average growth rate is the average of the annual real GDP (1995 price) growth rates in local currency unit. Hong Kong statistics are available from 1962 onward and Macau from 1983.
[a] For the period 1962–77.
[b] For the period 1983–2002.

Source: World Bank (2004).

TABLE 2
Per Capita Real GDP in Comparison at the National Level[a]

Year	*PRC*	*Hong Kong*	*Macau*	*Income Ratio*	
	US$	*US$*	*US$*		
	(1)	*(2)*	*(3)*	*(2)/(1)*	*(3)/(1)*
1955	62	n.a.	n.a.	n.a.	n.a.
1960	91	n.a.	n.a.	n.a.	n.a.
1965	87	3,723	n.a.	42.88	n.a.
1970	106	4,319	n.a.	40.73	n.a.
1975	127	6,029	n.a.	47.51	n.a.
1980	163	8,790	n.a.	53.93	n.a.
1985	253	12,017	12,082	47.51	47.77
1990	342	17,177	15,580	50.23	45.56
1995	568	22,416	16,962	39.43	29.84
2000	808	20,734	15,468	25.67	19.15
2001	861	20,197	15,621	23.46	18.15
2002	928	19,522	16,919	21.04	18.23
2003	1,100	23,194	18,136	21.07	16.48
2004	1,276	24,095	22,956	18.88	17.99

Notes:
1955–2002: real GDP per capita at 1995 constant prices in local currency converting to US dollars using 1995 exchange rate against the dollar. 2003–2004: current prices measured in US dollars; the figures in these two years cannot be compared with those in 1955–2002.
[a] China started its first economic census from 2004 and finished in March 2006. The census was the first time that China attempted to have the best estimate of its economy. According to the census, China's GDP in 2004 was 15.988 trillion RMB, which was 2.3 trillion or 16.8 per cent higher than the original official figure. Based on this new figure, China was the sixth largest economy in the world, ahead of Italy, with a total GDP of $1.93 trillion. NBS has adjusted China's GDP from 1993 to 2004 based on the census results and used a trend smoothing method to raise the GDP values back to 1993. As this paper uses data far before 1993, we do not have similar and comparable adjusted data before 1993. As a result, we have to stick to the original data published in the *China Statistical Yearbooks*. As all the variables in the econometric models will be in log forms, regression results will not be affected whether the data are adjusted or not.

Sources: World Bank (2004) for 1955–2002, NBS (2005) for 2003–2004.

by 2.46 percentage points. In the next decade of 1993–2002, the spread further increased to 7.29 per cent.

Although the Chinese economy grew faster than its two SARs, their income gaps were huge and did not decline until the 1980s. Starting from 1965, real GDP per capita in Hong Kong was 43 times that of China's ($3,723 versus $87). The income ratio rose to 54 by 1980 ($8,790 versus $163). The rising trend of inequality was arrested and turned around after China started its economic reforms. Fast economic growth and enhanced by the family planning policy, per capita real GDP of China has been increasing at a remarkable speed, while the growth in Hong Kong slowed down. Per capita real GDP in China increased to $808 in 2000. As a result, the income ratio between China and Hong Kong was more than halved from its peak of 54 in 1980 to 26.

As Hong Kong suffered an economic recession shortly after its handover to China in 1997, its per capita real GDP fell from $24,130 to $19,522 in 2002. At the same time, per capita real GDP of China rose to $928, reducing the income ratio further to 21. The continuous contraction in the income ratio represents reduced income disparity between the two economies. The income gap between China and Macau shares a similar declining pattern. The per capita income ratio between China and Macau was reduced by almost two-thirds in less than two decades from 48 in 1985 to 18 in 2002. The income gap was reduced further in 2003 and 2004 as China continued to outperform its two SARs.

b. Disparities at Regional Level

Table 3 reveals significant variations of per capita real GDP among the coastal, central and western provinces in China. The coastal region has the highest per capita income, but the income gaps among the three regions were not large in the pre-reform period.

In 1980, per capita real GDP in the coastal region was $187, which was respectively 39 per cent and 80 per cent higher than in the central and western regions. Economic reforms brought about better prospects to the coastal region,

TABLE 3
Per Capita Real GDP at Regional Level (US$)

Year	*Coastal*	*Central*	*Western*	*Hong Kong*	*Income Ratio*		
	(1)	*(2)*	*(3)*	*(4)*	*Coastal (4)/(1)*	*Central (4)/(2)*	*Western (4)/(3)*
1955	65	65	48	n.a.	n.a.	n.a.	n.a.
1960	99	94	69	n.a.	n.a.	n.a.	n.a.
1965	83	80	63	3,723	45	46	59
1970	103	92	66	4,319	42	47	65
1975	132	103	77	6,029	46	59	78
1980	187	135	104	8,790	47	65	84
1985	298	211	166	12,017	40	57	73
1990	414	270	228	17,177	42	66	75
1995	827	444	338	22,416	27	51	66
2000	1,288	686	482	20,734	16	30	43
2001	1,407	744	517	20,197	14	27	39
2002	1,555	813	559	19,522	13	24	35

Notes:
Real GDP per capita in 1995 constant price in local currency converted to US dollars ($) using 1995 exchange rate. *Coastal*: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Guangxi. Hainan is excluded due to incomplete data. *Central*: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan. *Western*: Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia and Xingjiang. Sichuan and Tibet are excluded due to incomplete data.

Sources: World Bank (2004). NBS (1980–2004, 1995), Hong Kong SAR Government (1967–2003).

allowing it to grow faster than the rest of the country. By 1990, per capita real GDP in the coastal region reached $414, or 53 per cent and 82 per cent higher than in the central and western regions respectively. Uneven regional economic development continued in the following decade, resulting in even more inter-regional income disparities. By 2002, per capita real GDP in the coastal region was $1,555, or 91 per cent and 178 per cent higher than in the central and western regions respectively.

When the bilateral income ratios between different Chinese regions and Hong Kong are compared, their sizes were rather close to each other in 1965, at 45, 46 and 59 for the coastal, central and western regions respectively. This similarity, however, did not last for long. The ratios changed to 47, 65 and 84 respectively in 1980, implying a significant deterioration in regional income distribution.

The situation was reversed after economic reforms as all the Chinese regions were able to grow faster than Hong Kong, reducing the bilateral income ratios to 40, 57 and 73 in 1985 respectively. The convergence trend continued in the following two decades. In 1996, the income ratios were reduced to 25, 46 and 63, and by 2002, to 13, 24 and 35.

However, it is important to note that despite a reduction of income inequality between China and Hong Kong, income inequality among the Chinese regions themselves rose, especially in the post-reform period. The per capita real GDP ratio among the East, Central and West regions was 1-1-0.74 in 1953, but changed to 1-0.72-0.56 in 1980 and then to 1-0.52-0.36 in 2002, implying that over time the East became richer whereas the Central and West poorer, with the West being the most disadvantaged. In 2002, for example, per capita real GDP in the West was only $559, compared to $1,555 in the East. The income gap was much wider in 2002 than in 1980 when per capita real GDP was $104 in the West and $187 in the East.

4. PARAMETRIC ANALYSIS ON INCOME CONVERGENCE

a. δ-Convergence

The CVs are derived from per capita real GDP of the Chinese provinces, Hong Kong and Macau in different regional groupings (Table 4). For greater China, the CV was rather stable in the pre-reform years at around 3. It started to decline in the post-reform period from 3.21 in 1978 to 1.92 in 2002. This evolution suggests a clear δ-convergence of per capita incomes after 1980.

Similar to Greater China, the CVs of different regional groupings of the Chinese provinces with Hong Kong and Macau were stable with similar values ranging from 2.3 to 2.5 prior to economic reforms. In 1978, the CVs for the coastal, central and western regions were at similar levels and stayed at 2.46, 2.54

TABLE 4
Coefficient of Variation by Group

Year	*Greater China*	*Coastal Region + SARs*	*Central Region + SARs*	*Western Region + SARs*
1961	3.3298	2.5745	2.5227	2.3237
1965	3.0606	2.4690	2.4213	2.2713
1970	2.9877	2.3527	2.4342	2.3005
1975	3.1594	2.4066	2.5344	2.3435
1978	3.2147	2.4553	2.5390	2.5906
1979	3.2899	2.4944	2.5544	2.6190
1980	3.3508	2.5214	2.5822	2.6302
1985	2.8231	1.9962	1.9241	1.9504
1990	2.8507	2.0043	1.9366	1.9611
1995	2.5653	1.8233	1.8991	1.9476
2000	2.1097	1.5575	1.7606	1.8530
2001	2.0060	1.4881	1.7235	1.8230
2002	1.9172	1.4260	1.6840	1.7906

Notes:
As the official survey started in 1982, Macau is covered in the measurement only after 1982. The relatively lower per capita real GDP of Macau (relative to Hong Kong) has then brought about a drop in CVs in 1982. *Greater China*: 30 provinces of China plus Hong Kong and Macau. *Coastal region + SARs*: 12 coastal provinces of China plus Hong Kong and Macau. The statistics of Hainan province are discussed only after 1978. *Central region + SARs*: 9 central provinces of China plus Hong Kong and Macau. *Western region + SARs*: 7 western provinces plus Hong Kong and Macau. Sichuan and Tibet are discussed only after 1978 due to data availability. Coverage of coastal, central and western regions is given in the notes to Table 3.

Sources: World Bank (2004). NBS (1980–2004, 1995), Hong Kong SAR Government (1967–2003), Macau SAR Government (1982–2003).

and 2.59 respectively. After economic reforms, the corresponding CVs declined to 2.00, 1.94 and 1.96 respectively in 1990, and further down to 1.43, 1.68 and 1.79 in 2002. The results further support the conclusion in the previous section that income inequality between the Chinese regions, Hong Kong and Macau has been declining since economic reforms. The results in Table 4 also suggest that the coastal provinces have a smaller income gap with Hong Kong and Macau than their central and western counterparts.

On the size of the CV, among all the indices in Table 4, the Greater China CV is the highest. This indicates the presence of a considerable income gap between the Chinese provinces, Hong Kong and Macau. This problem, however, has been easing since the economic reforms. Relative to the Greater China CV, the regional CV is smaller by 0.49, 0.23 and 0.13 units in 2002 for the coastal, central and western regions respectively. Perhaps the provinces within each of these regions have similar backgrounds and endowment, facing similar policies, having similar income levels, and may have even formed a geo-economic club with each other. As a result, the income inequality problem between each of these regions, Hong Kong and Macau is less serious than that exhibited in the Greater China economy.

b. β-Convergence

(i) Absolute income convergence

Table 5 presents cross-sectional regression results of equation (4) to test for absolute convergence using per capita real GDP of all the Chinese provinces, Hong Kong and Macau. Cross-sectional data are obtained for different time periods: pre-reforms 1961–77, post-reforms 1978–2002, and aggregate 1961–2002.

For the entire sample period 1961–2002, there is evidence of absolute convergence, but it appears that the convergence is mainly due to the reforms period 1978–2002. There is no evidence of convergence in the pre-reforms (1961–77). It is interesting to note that if we run the same regressions based on per capita real GDP of only the Chinese provinces without Hong Kong and Macau, we cannot find any evidence of convergence in both the reforms and pre-reform periods. Instead, we find evidence of divergence in the reform period. The results are not reported here but they are consistent with those found in Yao and Zhang (2001a). Consequently, the evidence of income convergence shown in Table 5 implies that the convergence in the reform period was entirely due to the narrowing income gaps between the Chinese regions and the two SARs, instead of inequality reduction among the Chinese provinces themselves.

In the lower panel of Table 5, all the regressions in the upper panel are repeated with a coastal dummy variable. This dummy variable does not reverse any of the estimation results but contributes to improve the explanatory power of initial income, as well as to increase the size of its estimated coefficient. A positive and

TABLE 5
Cross-sectional Regression: Chinese Provinces, Hong Kong and Macau

Time Period	*1961–1977*	*1978–2002*	*1961–2002*
Constant	0.734 (2.86)	2.922 (8.36)	3.775 (9.30)
Ln y_{0i}	–0.0262 (–0.45)	–0.196 (–2.856)	–0.254 (–2.78)
Implied λ	*0.0017*	*0.0091*	*0.0071*
Adjusted R^2	0.030	0.19	0.20
With Coastal Dummy			
Constant	0.832 (3.67)	3.365 (12.62)	4.024 (16.44)
Ln y_{0i}	–0.0766 (–1.43)	–0.325 (–5.87)	–0.381 (–6.61)
Coastal Dummy	0.280 (2.98)	0.496 (5.24)	0.703 (6.94)
Implied λ	*0.0050*	*0.016*	*0.012*
Adjusted R^2	0.21	0.58	0.72

Notes:
Dependent variable = $\ln y_{ti} - \ln y_{0i}$. *t*-Statistics are in parentheses. The estimations start from 1961 since data for Hong Kong are only available from this year onward.

Sources: NBS (1980–2004, 1995), Hong Kong SAR Government (1967–2003), Macau SAR Government (1982–2003).

TABLE 6
Panel Data Regression: Chinese Provinces, Hong Kong and Macau

Time Period	*1963–1977*	*1978–2002*	*1963–2002*
All Provinces with Hong Kong and Macau			
Constant	0.376 (4.25)	0.452 (9.57)	0.296 (7.50)
Ln y_{0i}	–0.033 (–1.74)	–0.024 (–3.11)	–0.030 (–1.42)
Implied λ	*0.0068*	*0.0049*	*0.001*
Adjusted R^2	0.024	0.052	0.03
Coastal Provinces with Hong Kong and Macau			
Constant	0.390 (3.70)	0.646 (9.05)	0.438 (7.83)
Ln y_{0i}	–0.027 (–1.26)	–0.050 (–4.63)	–0.023 (–2.52)
Implied λ	*0.0054*	*0.010*	*0.0046*
Adjusted R^2	0.016	0.23	0.049
Central Provinces with Hong Kong and Macau			
Constant	0.271 (2.67)	0.531 (8.76)	0.333 (6.04)
Ln y_{0i}	–0.020 (–0.96)	–0.040 (–4.22)	–0.015 (–1.65)
Implied λ	*0.004*	*0.0082*	*0.0031*
Adjusted R^2	–0.003	0.24	0.02
Western Provinces with Hong Kong and Macau			
Constant	0.341 (3.00)	0.456 (8.02)	0.375 (7.29)
Ln y_{0i}	–0.027 (–1.15)	–0.033 (–3.65)	–0.023 (–2.66)
Implied λ	*0.0054*	*0.0067*	*0.0047*
Adjusted R^2	0.014	0.19	0.073

Notes:
Dependent variable, $\ln y_{ti} - \ln y_{0i}$. *t*-Statistics are in parentheses.

Sources: NBS (1980–2004, 1995), Hong Kong SAR Government (1967–2003), Macau SAR Government (1982–2003).

significant coastal dummy in all the time periods regression models suggests that the growth pattern in the coastal region is different from that in other regions. The direct interpretation is that the coastal region is able to catch up with Hong Kong and Macau at a higher speed than the rest of the country. An indirect interpretation is that the coastal region is leading the Chinese provinces to catch up with Hong Kong and Macau, but in the meantime it also implies a rising trend of spatial inequality within China.

The same model (equation (4)) is also estimated with panel data at the national and regional levels. The results presented in Table 6 are not much different from those derived from the cross-sectional regressions although the speed of convergence is found to be slower from the national regression. There is no evidence of absolute income convergence prior to economic reforms during 1963–77 at both the national and regional levels. On the other hand, absolute income convergence is found in the post-reforms period 1978–2002 at all levels. It implies that the initially poorer Chinese regions can grow faster than the initially richer Hong Kong and Macau economies. Amongst them, the coastal region is able to catch

up with Hong Kong and Macau at the highest speed of 1 per cent a year, followed by the central region at 0.82 per cent and the western region at 0.67 per cent. In the meantime, the speed of income convergence for Greater China is just 0.49 per cent.

Why the speed of convergence is slower in the national regression than in the regional regression can be explained as follows. At the national level, economic reforms led to a rising inequality among the provinces within China but a declining inequality between the Chinese provinces with Hong Kong and Macau. As a result, the overall speed of convergence among the Chinese provinces, Hong Kong and Macau is the net effect of two counteractive forces: a diverging force among the Chinese provinces and the converging force among the Chinese provinces, Hong Kong and Macau. When the Chinese provinces are divided into different regions, the diverging force among the provinces within each region is reduced or removed. It is even possible that provinces within each region are converging themselves. As a result, the speed of convergence at the regional level is faster than at the national level.

(ii) Conditional convergence

Although we have found evidence of absolute income convergence, it is still useful to estimate equation (5) to test for conditional convergence and identify the key factors that influence economic growth. In the cross-sectional analysis, given absolute convergence, conditional income convergence is also found with statistically significant initial income level. The additional variables, however, are all statistically insignificant and the estimation results are not much different from those exhibited in Table 5 and are therefore not shown here.

Table 7 summarises the estimation results of panel data regressions for all the Chinese provinces and the three economic regions with Hong Kong and Macau. The results are consistent with those in Table 6. A catching-up process conditional to investment ratio and effective population growth is found between China, Hong Kong and Macau in both the pre- and post-reform periods. The growth determinants have the expected signs, with investments tending to accelerate while population growth to hold back growth. The speed of catching up between the Chinese provinces and the two SARs is slightly accelerated after controlling for investments and population growth, especially in the pre-reform period for China as a whole.

In Table 7, investment is found to have a significant and positive impact on regional economic growth in the post-reform period but not in the pre-reform period in all the regressions. Population growth is found to have a significant and negative impact on per capita income in both the pre-reform and post-reform periods for all the Chinese provinces with Hong Kong and Macau and in the post-reform period in the coastal provinces with Hong Kong and Macau, but not significant in all the other regressions. When the pre-reform and post-reform

TABLE 7
Panel Data Regression, Chinese Provinces with Hong Kong and Macau

Time Period	*1963–1977*	*1978–2002*	*1963–2002*
All the Provinces, Hong Kong and Macau			
Constant	–0.413 (–1.17)	–0.389 (–1.44)	–0.696 (–3.78)
Ln y_{0i}	–0.018 (–2.38)	–0.028 (–3.62)	–0.022 (–3.15)
Ln s_i	0.004 (0.13)	0.088 (2.76)	0.057 (2.83)
Ln$(n + g + \delta)_i$	–0.330 (–2.30)	–0.353 (–3.83)	–0.434 (–6.31)
Implied λ	*0.001*	*0.006*	*0.005*
Adjusted R^2	0.07	0.18	0.17
Coastal Provinces with Hong Kong and Macau			
Constant	–0.485 (–0.91)	0.163 (0.45)	–0.373 (–1.27)
Ln y_{0i}	–0.032 (–1.43)	–0.052 (–5.07)	–0.040 (–4.23)
Ln s_i	–0.054 (–0.62)	0.158 (3.21)	0.118 (3.33)
Ln$(n + g + \delta)_i$	–0.301 (–1.33)	–0.253 (–2.11)	–0.396 (–3.85)
Implied λ	*0.007*	*0.011*	*0.008*
Adjusted R^2	0.08	0.36	0.24
Central Provinces with Hong Kong and Macau			
Constant	0.977 (1.084)	0.465 (0.98)	–0.512 (–1.55)
Ln y_{0i}	–0.021 (–0.97)	–0.042 (–4.47)	–0.025 (–2.93)
Ln s_i	0.032 (0.78)	0.196 (2.89)	0.058 (1.76)
Ln$(n + g + \delta)_i$	0.246 (0.71)	–0.124 (–0.83)	–0.365 (–3.16)
Implied λ	*0.004*	*0.009*	*0.005*
Adjusted R^2	0.04	0.36	0.2
Western Provinces with Hong Kong and Macau			
Constant	–0.061 (–0.060)	0.294 (0.57)	–0.202 (–0.59)
Ln y_{0i}	–0.023 (–0.79)	–0.030 (–2.84)	–0.023 (–2.46)
Ln s_i	0.074 (0.57)	0.076 (1.12)	0.091 (1.54)
Ln$(n + g + \delta)_i$	–0.184 (–0.45)	–0.086 (–0.47)	–0.254 (–2.04)
Implied λ	*0.005*	*0.006*	*0.005*
Adjusted R^2	0.07	0.21	0.15

Notes:
Dependent variable ln y_{ti} – ln y_{0i}. t-Statistics are in parentheses.

Sources: NBS (1980–2004, 1995), Hong Kong SAR Government (1967–2003), Macau SAR Government (1982–2003).

periods are merged into one period (last column of Table 7), both investments and population growth are found to have a significant impact on economic growth in all the regional groupings regressions.

As discussed in the previous section, economic growth and income convergence are not only influenced by investments and population growth, but also by some other factors such as openness. Openness can be reflected by two important indicators, one is the trade/GDP ratio and the other is the inflows of FDI. The inflows of FDI are important for the Chinese provinces but not so important to Hong Kong and Macau. In addition, there is a close relationship between trade and FDI. To avoid the problem of multicollinearity and to ensure that the same

TABLE 8
Conditional Convergence Analysis, Panel Data in 1978–2002

Explanatory Variables	*All China, Hong Kong and Macau (1)*	*East, Hong Kong and Macau (2)*	*Central, Hong Kong and Macau (3)*	*West, Hong Kong and Macau (4)*
Constant	–0.131 (–0.53)	0.230 (0.63)	0.741 (1.55)	1.183 (2.39)
Ln y_{0i}	–0.105 (–7.47)	–0.105 (–4.99)	–0.102 (–3.77)	–0.101 (–4.98)
Ln s_i	0.070 (2.43)	0.112 (2.08)	0.176 (2.64)	0.092 (1.56)
Ln$(n + g + \delta)$	–0.427 (–5.15)	–0.313 (–2.58)	–0.154 (–1.05)	–0.042 (–0.27)
Ln(trade/GDP)	0.067 (6.43)	0.058 (2.47)	0.051 (2.07)	0.102 (4.01)
Implied λ	*0.021*	*0.021*	*0.019*	*0.017*
Adjusted R^2	0.36	0.41	0.40	0.42

Notes:
Dependent variable, ln y_{ti} – ln y_{0i}. *t*-Statistics are in parentheses. (1) All the Chinese provinces with Hong Kong and Macau; (2) The eastern Chinese provinces with Hong Kong and Macau; (3) The central Chinese provinces with Hong Kong and Macau; and (4) The western Chinese provinces with Hong Kong and Macau. The coverage of provinces in each region is defined in the notes to Table 3.

Sources: NBS (1980–2004, 1995), Hong Kong SAR Government (1967–2003), Macau SAR Government (1982–2003).

variable is relevant for the Chinese provinces, Hong Kong and Macau, the augmented growth model includes only one more additional variable, i.e. the trade/GDP ratio, to test whether openness as represented by international trade is important for regional economic growth and income convergence.

The augmented model is run using both cross-sectional and panel data. However, as the results from the panel data regression are more stable than those from the cross-sectional regression and the trade variable is only relevant in the post-reform period, Table 8 only reports the regression results based on the panel data regressions for the post-reform period 1978–2002. The same regression is repeated for different groupings of regions.

The results in Table 8 are striking in the sense that openness as measured by the trade/GDP ratio is found to have a significant impact on the process of income convergence among the Chinese provinces, Hong Kong and Macau at the national as well as the regional level. Comparing the results in Table 8 and the second column in Table 7, there are a number of important differences. The goodness-of-fit is much higher in all the regressions in Table 8, meaning that the impact of openness is not only significant but also sizeable. As a result, the speed of convergence is significantly increased in the presence of international trade. At the national level and in the eastern region, the pace of convergence increases from less than 1 per cent to 2.1 per cent. In the central and western regions, the pace of convergence rose from 0.9 per cent and 0.6 per cent to 1.9 per cent and 1.7 per cent respectively. The effects of investments and population growth are

similar in the two tables, but the estimated coefficients in Table 8 become more sizeable and significant after adding the trade variable. This implies that the regression model in Table 8 is a much better fit than that in Table 7. It also implies that openness is one of the most important factors that drive the economic growth in China and its income convergence with its two SARs.

c. Stochastic Convergence

To examine if per capita real GDP of China, Hong Kong and Macau have achieved stochastic convergence, per capita real GDP of China relative to that of Hong Kong and that of Macau are composed and tested to see whether the income ratios have a unit root. A time trend is also included to test whether the respective income ratios have a deterministic trend over time.

We first perform standard unit root tests for the log relative per capita GDP series. Following the '*t*-sig' method suggested by Campbell and Perron (1991) and Perron (1994 and 1997), we start with an upper bound, $p_{\max}$, on p, or the number of terms on ($\sum_{k=1}^{p} \beta_k \Delta \ln(yr)_{1t-k}$), which is determined *a priori*. If the last included lag is significant, choose $p = p_{\max}$. If not, reduce p by one until the last lag becomes significant. We set $p_{\max} = 8$ and use the two-sided 10 per cent value of the asymptotic normal distribution to assess the significance of the lag. The regression results are reported in Table 9. The best number of lags in each regression is given in the second column of the table.

TABLE 9
ADF Unit Root Test for Per Capita GDP Ratio in Logarithms

Dependent Variable = $\Delta \ln(yr)_t$	*Number of Lags (p)*	*Test statistics on* $\ln(yr)_{t-1}$	*Time Trend*
1967–1978			
Hong Kong/China	(5)	1.12	–0.0001
			(–1.11)
1978–2002			
Hong Kong/China	(4)	0.72	–0.0025
			(–2.07)**
1982–2002			
Macau/China	(3)	–5.16**	–0.015
			(–5.39)**

Notes:
The ADF test is based on equation (6) to test for unit roots in the logarithm of real per capita GDP ratio $(yr)_t$.
* Significance at the 5 per cent level, and ** 1 per cent level. Test statistics are the asymptotic ADF *t*-values used to test for unit roots. All the equations are estimated with an intercept and a time trend. Time trend = the estimated coefficients of time and their asymptotic *t*-values in parentheses.

Sources: NBS (1980–2004, 1995), Hong Kong SAR Government (1967–2003), Macau SAR Government (1982–2003).

The relative income ratio between China and Hong Kong is found to be non-stationary in both the pre-reform and reform periods. It indicates that there is no bivariate stochastic convergence between China and Hong Kong. The relative income ratio fails to return to its long-term steady-state level after a shock and the income levels of the two economies carry a stochastic diverging pattern.

Despite the absence of stochastic convergence of per capita incomes between China and Hong Kong, there is evidence that their income gaps declined over the reform period as shown by a negative and significant time trend coefficient. In the pre-reform period, there is no such evidence.

The income ratio between China and Macau during 1982–2002 is found to be stationary. This implies that the income ratio tends to move in the same steady state over the data period. Moreover, the income ratio also has a negative and significant deterministic trend, meaning that per capita incomes of the two economies gradually converged over the data period.

The implication of the regression results in Table 9 can be interpreted as follows. In the pre-reform period, China and Hong Kong were not in the same steady state of per capita income and their income gap was not reduced. In the post-reform period, the income gap was reduced but not sufficiently enough to make the two economies in the same steady state and it may require much more time for a stochastic convergence process to take place. However, the income ratio between China and Macau was already integrated into a steady state over the data period.

5. CONCLUSION

This paper is an attempt to study the process of income convergence among the economies of China, Hong Kong and Macau in a systematic way. This is an important issue in the literature as greater China has been the world's most dynamic and fast growing economy for more than a quarter of a century. China started from a very low level of economic development and its income gaps with Hong Kong and Macau were actually rising prior to economic reforms.

The success of the Chinese economic reforms has been widely studied in the literature and many authors have identified various factors that have contributed to China's economic success. The Hong Kong and Macau factor has been largely ignored in the debate, but it is important for China's economic growth for two reasons. First, Hong Kong and Macau act as China's mentors of economic growth. In the earlier years of economic reforms, Deng Xiaoping set up four special economic zones, Shenzhen, Shantao, Xiamen and Zhuhai. Two of these special economic zones are on the borders of Hong Kong and Macau. Shenzhen was a small fishery village on the border of Hong Kong before 1980, but it has now become the fourth largest economic powerhouse in China after Shanghai,

Beijing and Guangzhou. The development of Shenzhen benefited directly from its closeness to Hong Kong in terms of massive cross-border investments and the practice of free market and international trade.

One of the key features in China's economic growth is its openness and integration with the global economy. In the process of globalisation and openness, Hong Kong not only provides the required capital and technologies, but also a useful gateway for Chinese goods to the international markets. After the handover of Hong Kong and Macau to China in the late 1990s, the process of integration and cross-border capital, labour and commodity flows must have increased. Owing to the law of diminishing marginal returns on capital, it is inevitable that per capita income in Guangdong and then the rest of China will converge to the level of Hong Kong and Macau.

The convergence process is examined from different angles in this paper. The non-parametric analysis reveals that income inequality between China and its two SARs rose in the pre-reform period but started to decline from the 1980s. The income gaps have more than halved since economic reforms.

The non-parametric analysis reveals that the income ratios between China and Hong Kong rose in the pre-reform period but gradually declined after economic reforms. This pattern of income convergence is tested and supported by two alternative parametric regressions. The first parametric regression is the MRW augmented Solow growth model. Both cross-sectional and panel data regressions show the lack of convergence in the pre-reform period and strong evidence of convergence in the reform period. One striking result is that income convergence among China and its two SARs is a net result of two counteractive forces: the diverging effect among the Chinese provinces and the converging effect among these provinces with Hong Kong and Macau. In other words, when we compare per capita income between China and its two SARs, there is evidence of convergence in the reform period despite the fact that there has been a diverging tendency of per capita incomes among the Chinese provinces themselves. The diverging trend among the Chinese provinces is mainly due to the three large geo-economic regions of East, Central and West.

Investments, population growth and openness as measured by the trade/GDP ratio are important factors explaining inter-regional economic growth differentials. In particular, there is strong evidence that openness has a powerful impact on income convergence among China, Hong Kong and Macau. The rate of convergence of per capita income is only 1 per cent or less without openness, but it rises to 2.1 per cent with openness at the aggregate national level.

Another parametric analysis is the unit root test for the relative income ratios between Hong Kong and China, and between Macau and China. The first income ratio is found to be non-stationary in pre-reform and post-reform periods, although the income gap between Hong Kong and China was narrowing in the reform period. The lack of stochastic income convergence between Hong Kong

and China implies that it may take more time for the latter to catch up with the former and achieve the same steady state of income, which is found to have been achieved by the Macau and China income ratio.

The empirical results in this paper have important policy implications in the sense that China has successfully integrated its provinces with Hong Kong and Macau. This process of integration suggests that Deng Xiaoping's 'one country, two systems' policy has brought about not just political benefits but economic benefits as well.

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