Business cycle and inflation synchronisation in Mainland China and Hong Kong

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Abstract

This paper uses annual data spanning 1962 to 2003 to examine whether business and inflation cycles have become more similar in the Chinese provinces. We find evidence of synchronisation, but it appears that business cycles in a group of mainly north-western provinces have diverged from those in the rest of China. We also study whether Hong Kong has come to resemble other Chinese provinces. While the business cycle in the SAR seems to have synchronised with Mainland China, the dynamics of inflation remain different.

Keywords: China, Hong Kong, business cycles, inflation, synchronisation
JEL Classification: E32, R11

1 Introduction

The tremendous growth of Mainland China in recent decades has fundamentally transformed the economy as central planning has given way to, arguably, a largely market-driven economy. These deep structural changes raise questions regarding the behaviour of the business and inflation cycles at a regional level. Has the liberalisation of the economy made growth rates in the Chinese provinces more synchronised or less? Do prices behave similarly in the different regions or has their deregulation caused provincial inflation dynamics to diverge? Have inflation and business cycle movements become more volatile? This paper seeks to provide preliminary answers to these questions. We moreover study the synchronisation of economic developments in the Mainland and Hong Kong, which in 1997 became a Special Administrative Region of China.

The goal of the analysis is to provide an atheoretical, statistical description of the synchronisation of the business and inflation cycles in China. We thus seek to establish empirical regularities rather than test economic theory. To this end, the study uses annual income and inflation data for 30 Chinese provinces and Hong Kong spanning the period 1962 to 2003.

The paper is structured as follows. Section 2 reviews the literature on inflation and business cycles and discusses studies on regional differences in China. Section 3 presents the data used in the analysis. Section 4 studies the synchronisation of provincial business cycles and Section 5 that of regional inflation rates. We find evidence of synchronisation in both cases. Nevertheless, it appears that business cycles in some, mainly northern, provinces have become less closely tied to developments in the rest of China. Section 6 examines whether Hong Kong has begun to resemble other Chinese provinces. While there has been considerable synchronisation of the Hong Kong business cycle with that of the Mainland, price developments seem largely independent. Section 7 concludes.

2 Literature review

The paper most closely related to ours is Poncet [16], who studies the synchronisation of business cycles in Mainland China over the period 1992 to 2004. Using quarterly employ-

ment data, she finds evidence of synchronisation, but reports that a group consisting of the provinces Gansu, Guizhou, Ningxia, Qinghai, Shaanxi, Sichuan, Tibet and Yunnan shows low correlations with the rest of the country. Moreover, no synchronisation within this group is detected. To preview our results below, we identify a very similar group of provinces that display little synchronisation.

Poncet also explores the causes of business cycle synchronisation in China. She finds that, among other factors, similar production structures and fiscal policies as well as high mutual labour mobility contribute to the synchronisation of economic activity between two provinces.

While Poncet only considers the synchronisation of business cycles, Tang [18] also studies inflation synchronisation in China. He estimates provincial VARs on industrial output and the retail price index over the period 1990 to 1995 and, using Blanchard and Quah's [2] approach, retrieves a nominal and a real shock for each province and interprets the correlations of the real shocks as a measure of business cycle integration. Likewise, he argues that the correlation of the nominal shocks captures the synchronisation of inflation rates. Tang reports that there are two groups of provinces for which business cycles are synchronised and three groups where inflation rates follow a common trend, and it is remarkable how geography seems to determine their composition. The first business cycle group comprises Anhui, Fujian, Hunan, Jiangxi, Liaoning and Zhejiang. The second group is made up of Gansu, Guizhou, Qinghai, Shaanxi and Xinjiang. The provinces with similar inflation developments are Beijing, Guangdong, Shanghai and Tianjin; Anhui, Jiangsu and Zhejiang; and Guangxi, Hunan and Sichuan. While we find below that inflation has become synchronised nation-wide, Tang's first group of provinces with unusual business cycles resembles ours.

The literature on economic activity in the different Chinese provinces typically concentrates on explaining the disparities in growth rather than common factors (useful reviews are found e.g. in Wang [20] and Wu [19]). Démurger et al [5] for instance study income inequality in China using data spanning 1952 to 1998. Their study suggests that by the end of the 1990s regions with similar locations and government policies had converged,

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while inequality between coastal and landlocked provinces persisted.[1] The authors argue that inefficient capital allocation by the banking sector and low labour mobility, caused by the government system of residence permits, are major factors preventing national convergence. They also show that the eastern provinces grew from 1992 onwards faster than the rest of China because they received most of the foreign investment that started to flow into the country.

The question whether the national business cycle of China has become more similar to that elsewhere is addressed by Zhang [22], who examines the origins of shocks affecting Chinese economic activity. He finds that most fluctuations in the business cycle are due to internal shocks, which he interprets as evidence of little synchronisation of Chinese economic activity with foreign business cycles. Kim, Kim and Wang [13] follow Frankel and Rose [6], who argue that countries with close trade links experience similar business cycles, and examine whether synchronisation has increased in the Asia-Pacific region.[2] Comparing the correlations in business cycles for the samples 1980 to 1989 and 1990 to 2001, they find that the correlation between Mainland China and Hong Kong (as well as Taiwan) has increased. Moreover, they report that business cycles in the Asia-Pacific region in general have become more synchronised, which they argue is due to correlated capital flows.

Oppers [15] discusses macroeconomic cycles in China and reviews the link between inflation developments and the national business cycle from 1979 to 1997. We draw extensively on his study when reviewing inflation in the Chinese provinces in Section 5. Oppers estimates a Phillips curve that splits the output gap in three components of aggregate demand– fixed investment, retail sales and exports – and he finds that the higher the demand pressure, the higher inflation. Imai [11] suggests that inflation in Mainland China is driven mainly by investment, while Ha, Fan and Shu [9] argue that inflation in

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[1]Wu [19] points out that the results on regional disparities depend strongly on whether or not data for Beijing, Shanghai and Tianjin are included in the analysis. Aziz and Duenwald [1] discuss this bipolarity of the income distribution in some detail.

[2]Calderon, Chang and Stein [3] examine the impact of trade integration on business cycle synchronisation for a set of 147 countries over the period 1960 to 1999 and find strong evidence in favour of a positive linkage.

the 1990s was caused by rising world prices and the devaluation of the renminbi in 1994. Gerlach and Peng [7], using a sample covering the period 1978 to 2003, also estimate the impact of economic activity on inflation in China, but find that a standard Phillips curve seems to fit the data only if it is assumed that some additional, unobserved factor impacts on price developments. They argue that this factor could represent the deregulation of prices, the opening up to trade etc.

There have apparently been no studies comparing inflation rates in the individual Chinese provinces. Ha and Fan [8], however, study price differentials between Hong Kong and four Mainland cities (Beijing, Guangzhou, Shanghai and Shenzhen) over the period 1994 and 2001. They find that the price differentials between Hong Kong and these cities have declined, but that the speed of convergence with Hong Kong is much smaller than that between the cities within Mainland China. They suggest as one factor explaining this phenomenon limited factor mobility.

3   The data

Figures 1 to 3 show the data used in the following analysis of business cycle and inflation synchronisation in China. Figure 1 plots the growth rates of real GDP in Anhui, Beijing, Chongqing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hainan, Hebei, Heilongjiang, Henan, Hubei, Hunan, Inner Mongolia, Jiangsu, Jiangxi, Jilin, Liaoning, Ningxia, Qinghai, Shaanxi, Shandong, Shanghai, Shanxi, Sichuan, Tianjin, Xinjiang, Yunnan and Zhejiang for the years 1962 to 2003. These data are from the CEIC database [4] and the Chinese statistical year book. We do not use data for Tibet since they start after 1962. Moreover, we treat Guangdong and Hainan, and Sichuan and Chongqing, as one province respectively, since Hainan and Chongqing became provinces in their own right during the sample period. We consider thus 28 time series and refer to them as the provincial data. Figure 2 shows the inflation rates computed from the regional GDP deflators.

Since it is the aim of this paper to study the synchronisation of economic activity and price developments in China, we abstain from discussing the individual graphs presented here. Instead, Sections 4 and 5 review economic events by assessing trends in the country

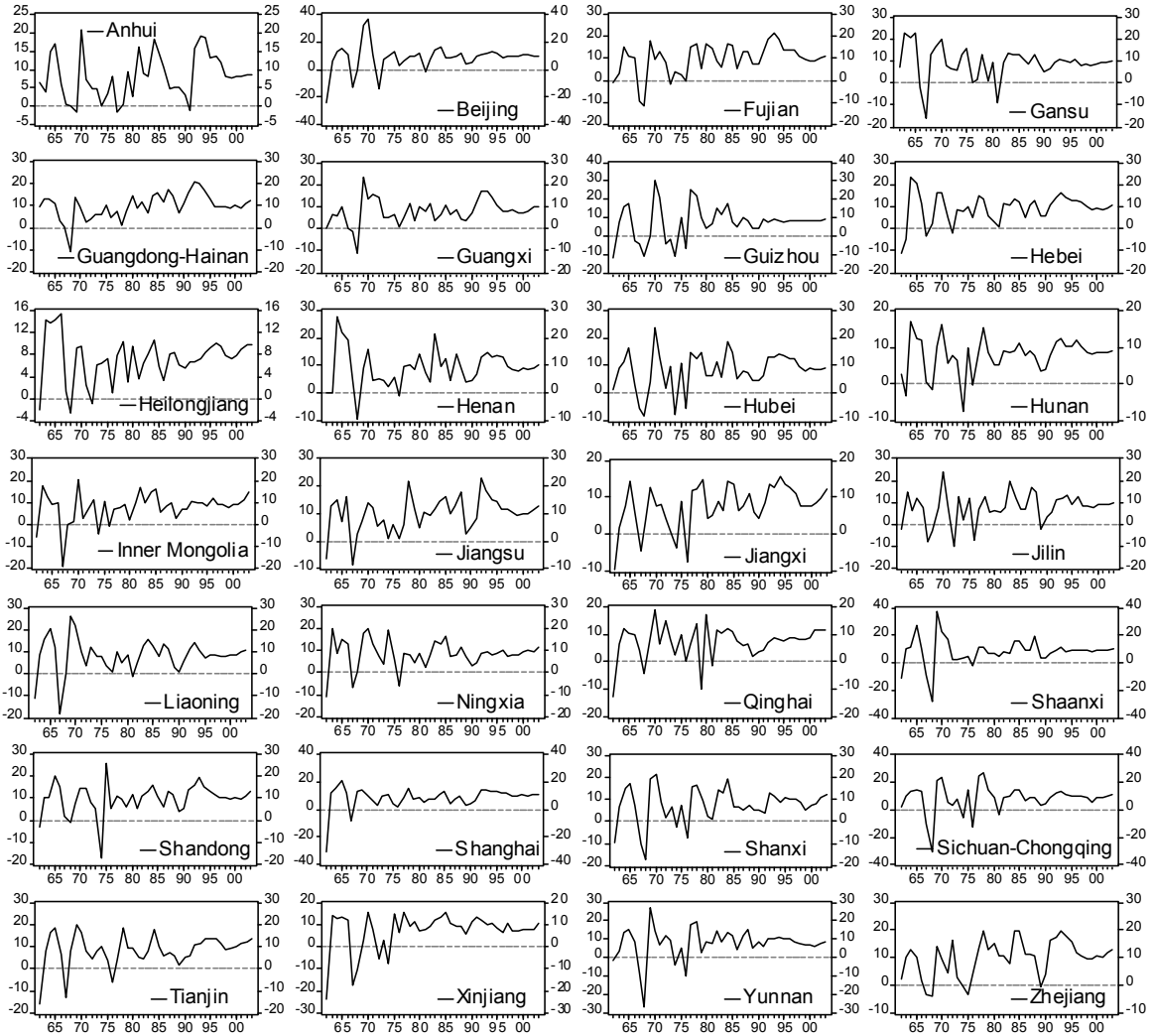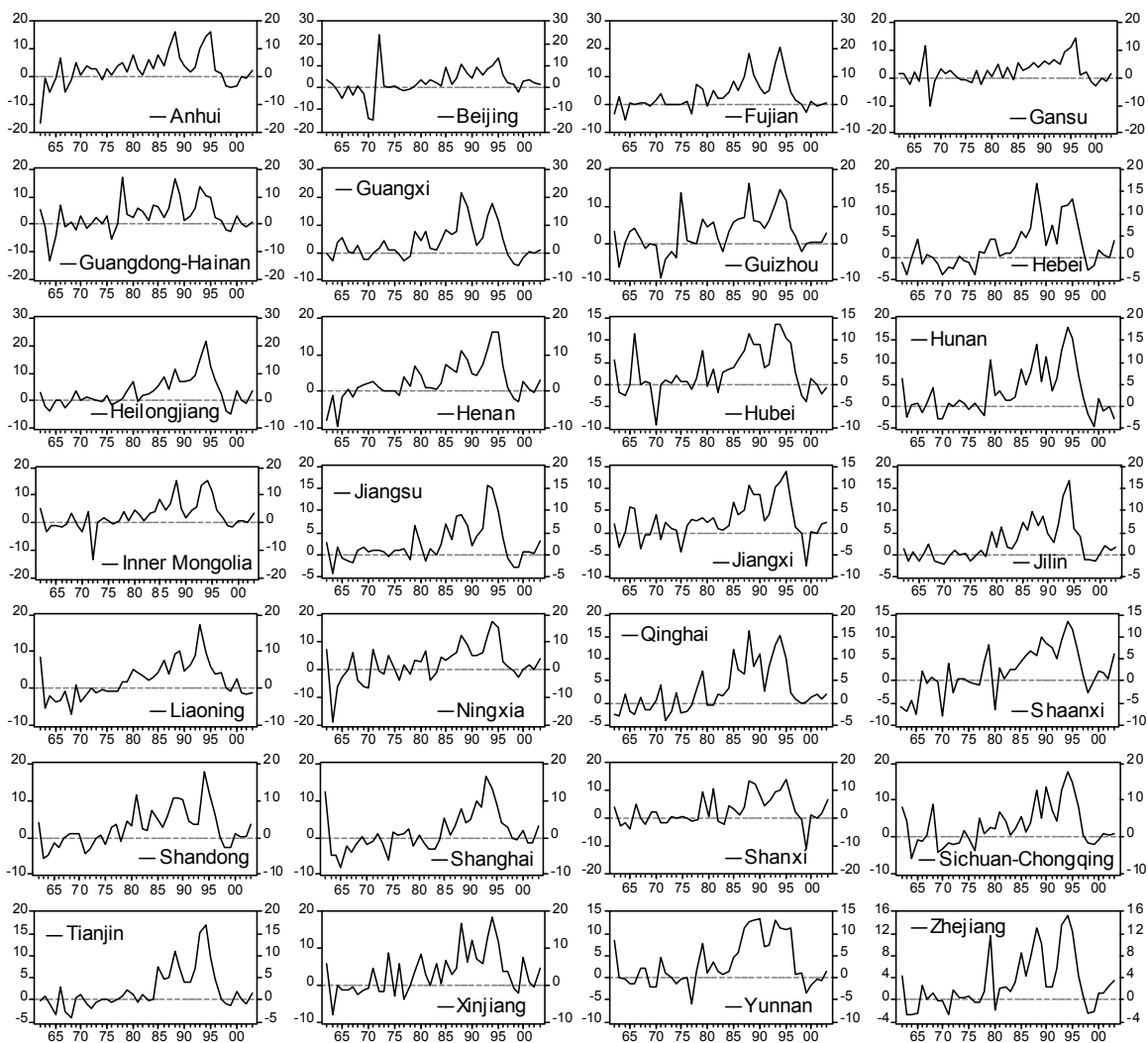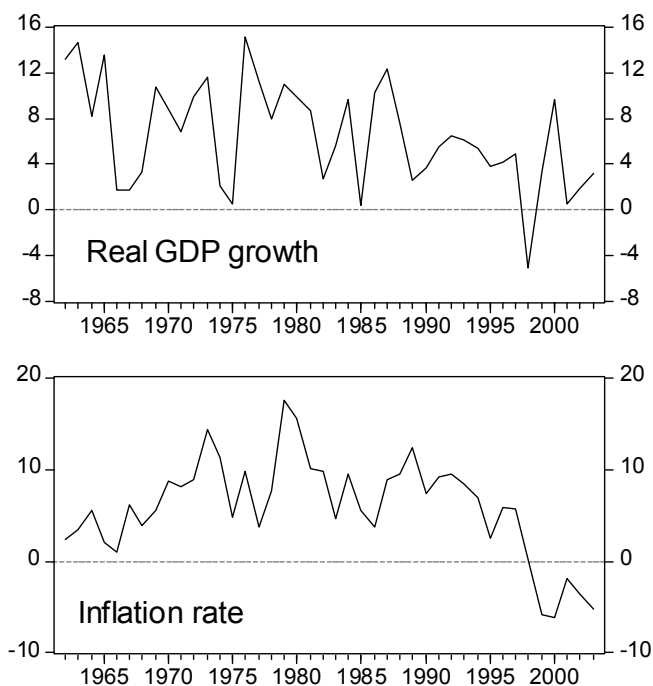Figure 1: Provincial real GDP growth

Figure 2: Provincial inflation rates

as a whole. Figure 3 shows real GDP growth and GDP deflator inflation in Hong Kong. These data, which we discuss in detail in Section 6, are from the website of the Hong Kong Census and Statistics Department [10].

Figure 3: Real GDP growth and inflation in Hong Kong

4   Business cycle synchronisation

To gain a sense of the common elements of the business cycles in the Chinese provinces, we present in the upper plot of Figure 4 the 28 regional growth rates shown in Figure 1 in one graph. The lower graph of Figure 4 plots the minimum, mean and maximum growth rate for each year.

Most provincial GDP growth rates were negative in 1962 and then recovered quickly to an average of 15.6% in 1965. This swing reflects the economic revival after the Great Leap Forward, which had been initiated in 1958 and which had brought the collectivisation of large parts of the economy. The emphasis on industrial output at the expense of agricultural production had been an important factor in the famine of the years 1959 to 1961. Chinese GDP shrank again in 1967 and 1968, when the Cultural Revolution greatly

hampered production, but activity recovered in the following years. Real GDP growth dropped to an average of -1.0% in 1976, the year of Mao's death, but increased to over ten percent the following year.

From the end of the 1970s onwards, China gradually opened to the world economy, and the average of the regional GDP growth rates is positive for the rest of the sample. Nevertheless, we still record swings in activity. The clearest slowdown in the second half of the sample is observed for 1989, when average growth decelerated to 4.1%. This coincides with tight monetary conditions at the time that were geared to reducing inflation (see Section 5 for details). At the end of the sample, the mean rate of the provincial growth rates was 10.9%, and the individual provincial growth rates lay between 8.3% and 15.1%.

Figure 4: Range of provincial GDP growth rates
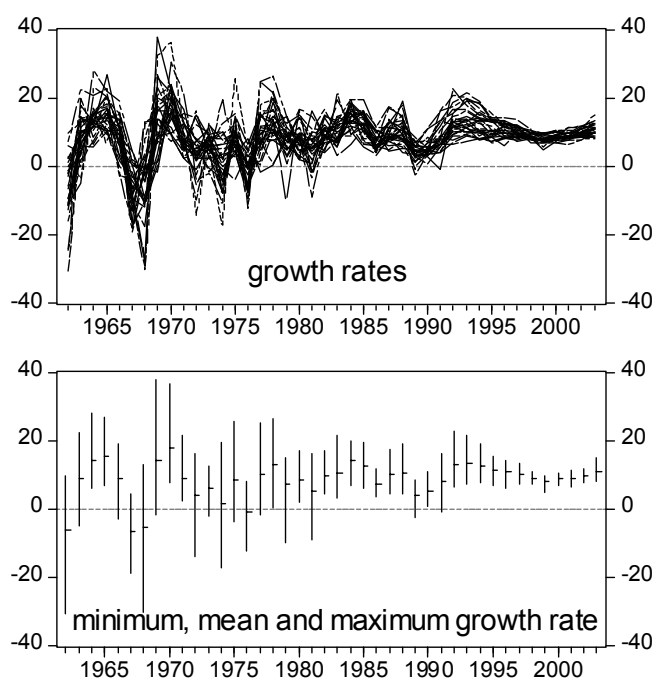
Focussing on the range of growth rates, we see that the minimum and maximum were more than thirty percentage points apart at the beginning of the sample. This distance narrowed from the end of the 1970s onwards, and it thus appears that regional growth rates became more similar once the first market-oriented reforms were introduced in 1978. Figure 5, which shows in the top plot the standard deviation of growth rates, confirms

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this impression.[3] The standard deviation shows a clear downward trend from the end of the 1970s onwards.

Figure 5 also suggests that growth has become less erratic over time. The second plot shows that the first autocorrelation has risen from basically zero in the first half of the sample to 0.81 in 2003. Finally, the last plot in Figure 5 shows that the distribution of growth rates in any given year has frequently had a kurtosis of more than 3 before 1980, indicating a distribution with fat tails (a normal distribution has a kurtosis of 3). This has given way to a situation in which outliers are rarer.

Figure 5: Summary statistics of provincial growth rates
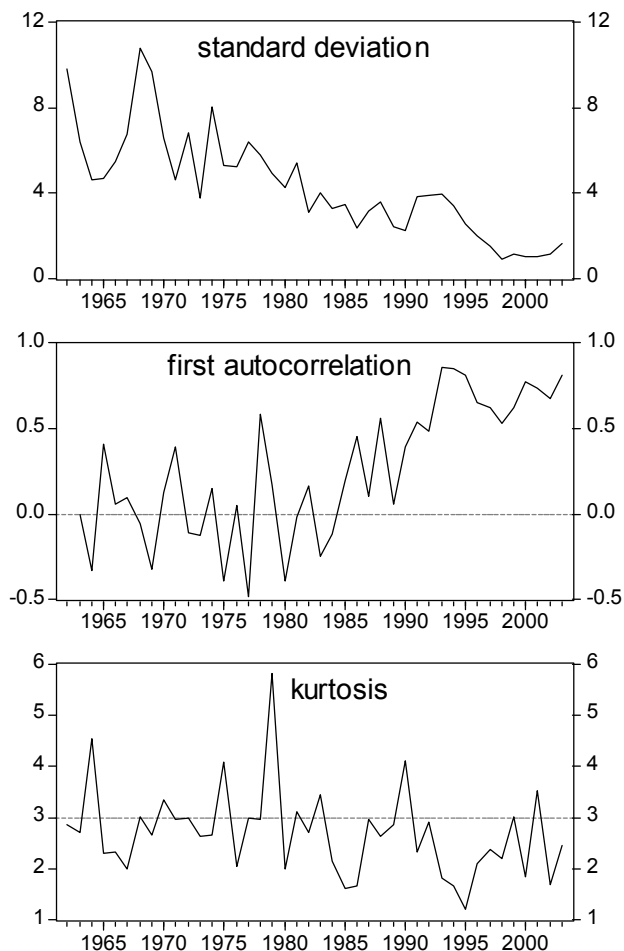
China's growth performance since the 1970s has been impressive. The National Bureau

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[3]Studies on regional disparity consider besides the standard deviation of regional growth rates the coefficient of variation, the Gini coefficient and the Theil index (see e.g. Wu [19]).

of Economic Research (NBER) defines as a recession in the US two consecutive quarters of negative growth. The last Chinese province to experience a negative growth rate was Anhui in 1991 (-1.0%). However, it seems likely that the NBER approach may not be appropriate to capture economic downturns in China since growth rates of e.g. 4 percent, which in more developed economies would be seen as evidence of a booming economy, have come to be thought of as poor performance in the context of China. We therefore consider fluctuations around a trend growth rate to capture regional business cycles.

To obtain these provincial output gaps, we first calculate for each province potential GDP. Denoting the logarithm of real GDP in province j in year t by $x_{j,t}$, we apply the Hodrick-Prescott filter with a smoothing parameter of 100 to obtain the logarithm of potential, $x_{j,t}^*$. The output gap for province j is then given by

$$y_{j,t} = x_{j,t} - x_{j,t}^*.$$

A negative output gap indicates a recession, a positive gap an overheating of the economy.

Figure 6 shows the 28 $y_{j,t}$:s used in the following analysis. Not surprisingly, this plot is very similar to that of the real GDP growth rates presented in Figure 4. We again find that most provinces experienced a large downturn during the Cultural Revolution and a small recession in 1976. We also identify economic slowdowns around 1981 and 1989, when credit conditions were tight since the authorities attempted to reduce inflation. Finally, there was a small downturn in 1998 and 1999, which might reflect the impact of the Asian financial crisis.

Figure 6: Provincial output gaps
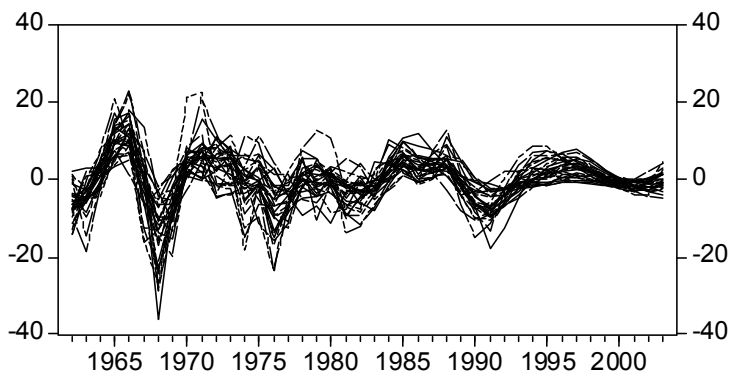
Given the similarity of the business cycles fluctuations in the individual provinces, especially towards the end of the sample, the question arises whether they are driven by one common factor. If a dominant common factor is identified, this can be thought of as the Chinese business cycle, and it then is possible to analyse which provinces have synchronised with this benchmark cycle and which, if any, have diverged.

It should be pointed out that the approach of identifying one common component and using this as a measure of the benchmark business cycle is preferable to using an output gap constructed on nation-wide Chinese data. The reason for this is that the latter measure basically is a weighted average of the regional output gaps, with the weights related to the level of provincial GDP. Assume, however, that one province follows a very different business cycle from the rest of the country. While the principal components analysis applied below would give that province a weight of zero in the construction of the common factor and identify this region as an outlier, the national output gap would include its data.

4.1 Principal components analysis

We use the principal components procedure to decompose the 28 $y_{j,t}$:s into 28 orthogonal factors, where the first of these, denoted as $Y_{1,t}$, is that linear combination of the underlying indicator series which explains the largest fraction of their variances.[4] This fraction of variances is given by

$$\varphi_1^y = \frac{l_1^y}{\sum\limits_{k=1}^{28} l_k^y},$$

where l_k^y denotes the kth largest eigenvalue of the covariance matrix of the $y_{j,t}$ series. The left panel of Table 1 shows φ_1^y and φ_2^y and the factor loadings of $Y_{1,t}$ and $Y_{2,t}$ (we concentrate on φ_1^y and φ_2^y for compactness).

To understand the principal components analysis, consider the first line of results in the left panel. The first number, φ_1^y, indicates that $Y_{1,t}$ explains 62.7% of the variance of the 28 $y_{j,t}$:s (implying that the other 27 $Y_{k,t}$:s together explain the remaining 37.3%). The second principal component, $Y_{2,t}$, captures 9.1% of the variance of the business cycle

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[4]For a discussion of principal components analysis, see e.g. Johnston [12].

fluctuations in the Chinese provinces. It thus appears that $Y_{1,t}$ captures the great bulk of movements in the provincial output gaps. Hence, we may think of this factor as representing the Chinese business cycle.[5]

The lower part of Table 1 reports the weights the individual provinces have in the construction of $Y_{1,t}$ and $Y_{2,t}$. The loadings $b_{j,1}^y$ correspond to the elements of the first eigenvector of the covariance matrix of the $y_{j,t}$:s and have been normalised such that they sum to unity. Interestingly, the weights for $Y_{1,t}$ are rather similar across provinces, ranging between 0.02 and 0.06, and they all differ significantly from zero.[6] This suggests that no individual province dominates this principal component and that all regions contribute to this common business cycle. By contrast, the weights in the construction of $Y_{2,t}$ vary widely, namely between -10.20 for Gansu and to 6.23 for Henan. Interestingly, many loading factors of the second principal component are insignificantly different from zero. Besides Gansu and Henan, Beijing, Fujian, Hubei, Hunan, Jiangxi, Jilin, Liaoning, Ningxia, Qinghai, Shaanxi, Shandong and Zhejiang have a weight that is significant. Interestingly, we find a positive $b_{j,2}^y$ for the eastern of these provinces (Fujian, Henan, Hunan, Hubei, Jiangxi, Shandong and Zhejiang) and a negative weight for the remaining, northern, provinces (Beijing, Gansu, Jilin, Liaoning, Ningxia, Qinghai and Shaanxi). It thus appears that $Y_{2,t}$ captures economic shocks particular to the east and the north of China.

We plot $Y_{1,t}$ and $Y_{2,t}$ in Figure 7. The first principal component shows an increase of economic activity in 1962 and a large downturn in 1967/68. These movements reflect the recovery from the Great Leap Forward mentioned above and the beginning of the Cultural Revolution. $Y_{1,t}$ also is negative during the episodes of monetary tightening around 1981 and 1989 as well as after the Asian financial crisis.

The second principal component displays little variation in the second half of the sample. In the first half, it shows peaks in 1968, 1972 and 1981 and a trough from 1974 to 1976. Comparing $Y_{2,t}$ with the output gaps of the individual provinces, we find that those

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[5] The correlation between $Y_{1,t}$ and the output gap for China as a whole is 0.96.

[6] The standard errors for the loading vector $b_{j,k}^y$ are given by $l_j^y \sum_{i \neq j}^{28} l_i^y b_{i,k}^y b_{i,k}^{y\prime} / (l_i^y - l_j^y)^2 / T$, where T is the sample length (see Mardia et al [14], p. 230).

Table 1: Principal components analysis

	$Y_{1,t}$	$Y_{2,t}$		$P_{1,t}$	$P_{2,t}$
φ_k^y	0.627	0.091	φ_k^p	0.690	0.047
$b_{Anhui,k}^y$	0.034***	2.115	$b_{Anhui,k}^p$	0.035***	-4.363
$b_{Beijing,k}^y$	0.040***	-8.329***	$b_{Beijing,k}^p$	0.030***	4.004
$b_{Fujian,k}^y$	0.040***	4.749**	$b_{Fujian,k}^p$	0.042***	-2.003**
$b_{Gansu,k}^y$	0.032***	-10.204***	$b_{Gansu,k}^p$	0.021***	0.694
$b_{Guangdong-Hainan,k}^y$	0.023***	-0.487	$b_{Guangdong-Hainan,k}^p$	0.034***	-1.142
$b_{Guangxi,k}^y$	0.029***	-2.287	$b_{Guangxi,k}^p$	0.044***	-0.793
$b_{Guizhou,k}^y$	0.051***	4.337	$b_{Guizhou,k}^p$	0.036***	0.031
$b_{Hebei,k}^y$	0.027***	1.334	$b_{Hebei,k}^p$	0.036***	-0.502
$b_{Heilongjiang,k}^y$	0.016***	2.103	$b_{Heilongjiang,k}^p$	0.040***	-0.068
$b_{Henan,k}^y$	0.035***	6.227**	$b_{Henan,k}^p$	0.037***	-2.049
$b_{Hubei,k}^y$	0.045***	2.909**	$b_{Hubei,k}^p$	0.036***	0.727
$b_{Hunan,k}^y$	0.027***	3.766***	$b_{Hunan,k}^p$	0.041***	0.788
$b_{Inner\ Mongolia,k}^y$	0.036***	-2.149	$b_{Inner\ Mongolia,k}^p$	0.035***	-0.881
$b_{Jiangsu,k}^y$	0.034***	2.590	$b_{Jiangsu,k}^p$	0.032***	0.021
$b_{Jiangxi,k}^y$	0.028***	3.853**	$b_{Jiangxi,k}^p$	0.030***	-0.482
$b_{Jilin,k}^y$	0.035***	-3.407**	$b_{Jilin,k}^p$	0.031***	0.228
$b_{Liaoning,k}^y$	0.040***	-8.861***	$b_{Liaoning,k}^p$	0.033***	1.839
$b_{Ningxia,k}^y$	0.029***	-8.044***	$b_{Ningxia,k}^p$	0.045***	1.374
$b_{Qinghai,k}^y$	0.023***	-3.257*	$b_{Qinghai,k}^p$	0.038***	-1.229
$b_{Shaanxi,k}^y$	0.053***	-5.924**	$b_{Shaanxi,k}^p$	0.035***	-0.575
$b_{Shandong,k}^y$	0.029***	5.335***	$b_{Shandong,k}^p$	0.035***	0.143
$b_{Shanghai,k}^y$	0.025***	1.240	$b_{Shanghai,k}^p$	0.034***	2.575*
$b_{Shanxi,k}^y$	0.051***	0.063	$b_{Shanxi,k}^p$	0.036***	0.095
$b_{Sichuan-Chongqing,k}^y$	0.057***	4.019	$b_{Sichuan-Chongqing,k}^p$	0.037***	1.132
$b_{Tianjin,k}^y$	0.037***	-2.172	$b_{Tianjin,k}^p$	0.034***	-0.542
$b_{Xinjiang,k}^y$	0.036***	3.309	$b_{Xinjiang,k}^p$	0.039***	0.634
$b_{Yunnan,k}^y$	0.046***	0.111	$b_{Yunnan,k}^p$	0.037***	1.320
$b_{Zhejiang,k}^y$	0.040***	6.060**	$b_{Zhejiang,k}^p$	0.037***	0.025

Note: φ_k denotes the fraction of the variance of the signal variables captured by the kth principal component. The factor loadings $b_{j,k}$ are obtained from the normalised first eigenvector of the covariance matrix of the signal variables. */**/*** denotes significance at the ten / five / one percent level.

Figure 7: First and second principal component of provincial output gaps
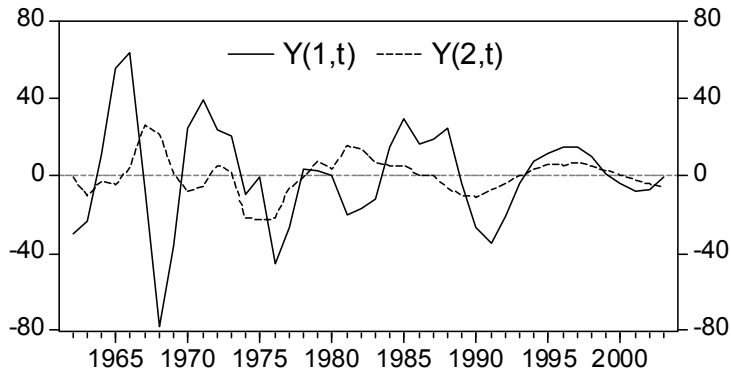
regions with a positive $b_{j,2}^y$ tend to display a positive output gap in 1972 and a negative gap in 1976. Those provinces with a negative loading weight on $Y_{2,t}$, by contrast, show unusually strong recessions in 1968 and 1981 and a large recovery in 1970.

To gain a better sense of the synchronisation of the provincial business cycles, we plot in Figure 8 the evolution of φ_1^y over time. The larger φ_1^y, the more does the first principal component dominate the movements in the output gaps in the 28 provinces and hence the more are the business cycles coordinated. To obtain a time series of φ_1^y, we perform the principal components analysis repeatedly using a ten-year rolling time window. The first value of φ_1^y is calculated from the output gap data of the years 1962 to 1971, the second value for the sample 1963 to 1972 and so on. The time axis in Figure 8 shows the end year of the moving window.

Figure 8: Importance of the first principal component of provincial output gaps

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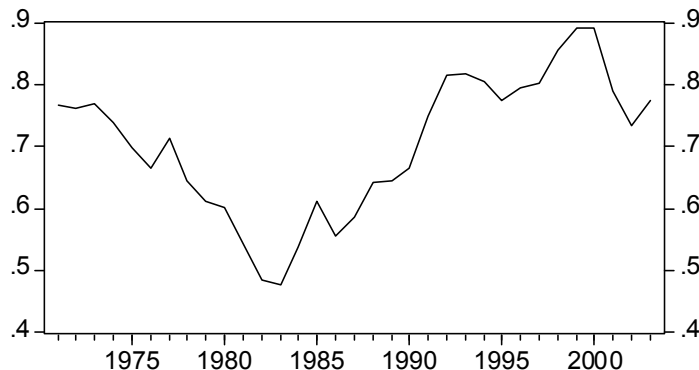
We find that φ_1^y falls from over 75 percent for the sample 1962 to 1971 to below 50 percent for the sample 1974 to 1983. The importance of $Y_{1,t}$ increases to almost 90 percent for the sample 1991 to 2000 and then again falls below 80 percent. This analysis suggests that in the 1960s, provincial business cycles were mainly driven by one common factor, which arguably was determined by political events. In the 1970s and 1980s, regional factors seem to have gained importance, which may have reflected at first a loss of central control due to the Cultural revolution and, towards the end of the 1970s, the gradual abandonment of central planning. From the late 1980s onwards, when market forces gained more and more importance, the provincial output gaps appear to have evolved again in a similar fashion.

Despite this overall synchronisation, it is possible that the output gaps in some provinces have over time become less closely related to the common business cycle. Figure 9 shows the correlation between the 28 $y_{j,t}$:s and $Y_{1,t}$. We again use a ten-year moving window to obtain these series.

The correlations between the output gaps in the individual provinces and $Y_{1,t}$ were almost always positive. The two largest exceptions are found for Anhui and Guangdong-Hainan for ten-year windows ending in the early 1980s. Furthermore, the correlations for Guizhou, Ningxia and Qinghai turn negative at the end of the sample.

For the majority of provinces Figure 9 shows an increase in correlation over time. Thus, as suggested by the analysis of φ_1^y, provincial business cycles in China have become more similar. Nevertheless, we find for a number of provinces a trend away from the common component. Economic activity in Heilongjiang, Ningxia, Shaanxi and Xinjiang, all northern and north-western provinces, has since the 1970s become less synchronised with the rest of China. Two further north-western provinces, Inner Mongolia and Qinghai, and the south-western province of Guizhou have shown a similar divergence since the end of the 1990s. These findings match Poncet [16] and Tang [18], who identify similar groups of unsynchronised provinces. In accordance with Poncet but in contrast to Tang, inspection of the output gaps of our seven provinces does not suggest that they have follow a common business cycle of their own.

Figure 9: Correlations between provincial output gaps and first principal component
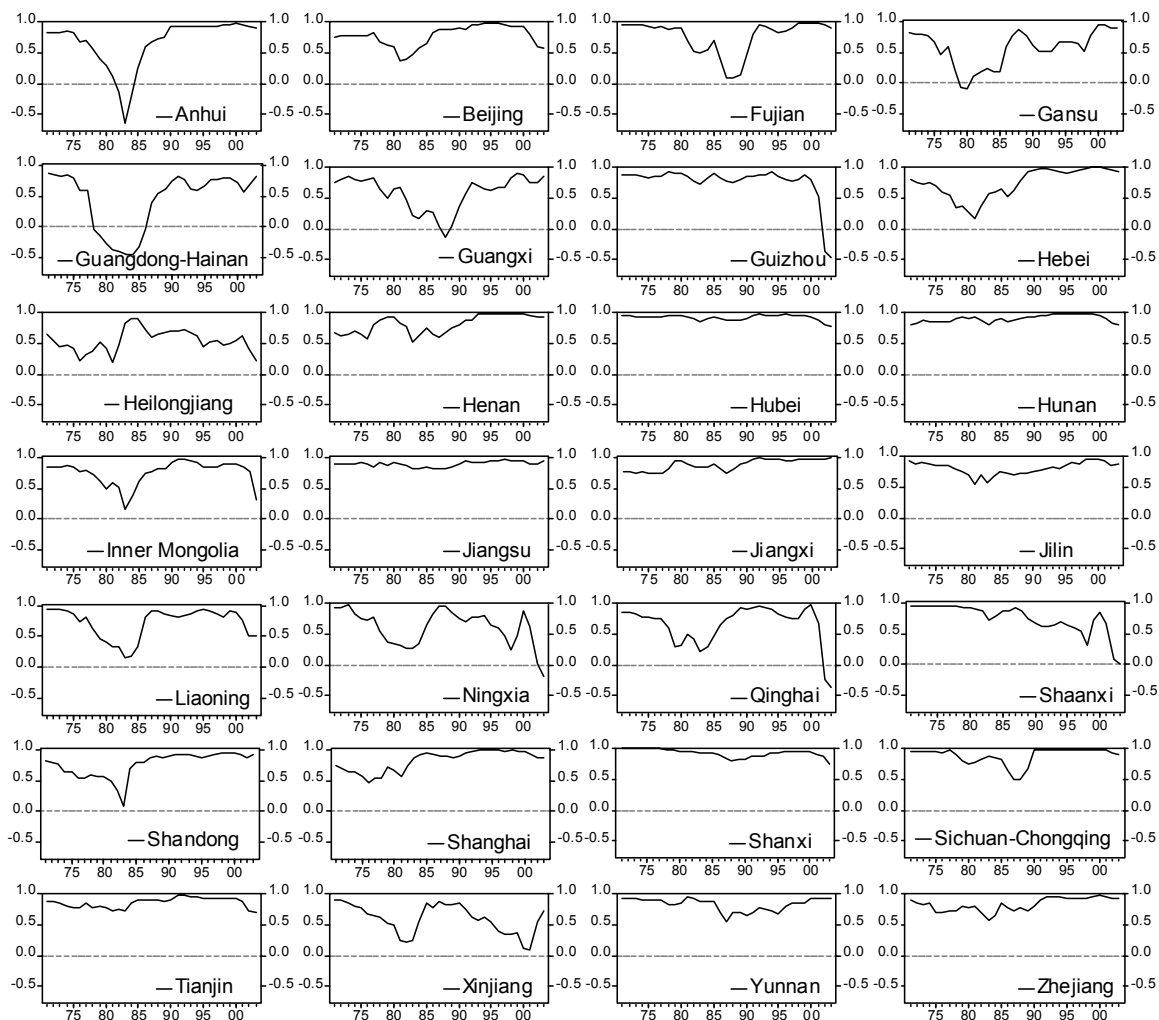
4.2 Unobservable components analysis

Section 6 studies whether Hong Kong's business cycle has become more synchronised with that of Mainland China. For this exercise, it is desirable to assess whether the output gap in Hong Kong differs significantly from the common Chinese component, and to answer this question, we need an estimate of how much uncertainty is attached to $Y_{1,t}$. We next re-estimate this common factor using the unobservable components technique proposed by Stock and Watson [17], which provides us with a measure of uncertainty.

We assume that each regional output gap reacts to an unobserved component Z_t and an innovation, i.e.

$$y_{j,t} = \beta_j^y Z_t + e_{j,t}, \tag{1}$$

where the response coefficient β_j^y and the variance of $e_{j,t}$ vary between provinces.[7] Since $Y_{1,t}$ displays significant first autocorrelation, we assume that Z_t follows an AR(1), i.e.

$$Z_t = \alpha_y Z_{t-1} + u_t. \tag{2}$$

Note that we do not include a constant since the output gaps have a mean close to zero.

The 28 equations given by expression (1) can be thought of as observation equations in a state space model, while equation (2) is the state equation. We estimate the resulting state space model using the Kalman filter and choose as normalising restriction $\beta_{Beijing}^y = 1$. The left panel in Table 2 shows the estimated reaction coefficients of the different provinces. We find that the β_{Gansu}^y and $\beta_{Heilongjiang}^y$ are insignificant, but that all other reaction coefficients differ significantly from zero. The unobserved output gap for the Chinese provinces has the smallest significant impact on Guangdong-Hainan, while the province to react most strongly to Z_t appears to be Sichuan-Chongqing. Figure 10 shows the smoothed estimate of Z_t together with $Y_{1,t}$.[8] The two estimates of the common business cycle component are very similar. In fact, $Y_{1,t}$ lies within the 95% confidence band of Z_t for most of the time.

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[7]Note that this assumption distinguishes the unobservable from the principal components analysis. In the latter, we had that $y_{j,t} = \sum_{k=1}^{28} b_{j,k}^y Y_{k,t}$.

[8]We normalise $Y_{1,t}$ so that its mean and standard deviation equal the average mean and standard deviation of the 28 $y_{i,t}$:s.

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Table 2: Unobservable component model

α_y	0.516***	α_p	0.851***
β^y_{Anhui}	0.931***	β^p_{Anhui}	1.287**
$\beta^y_{Beijing}$	**1**	$\beta^p_{Beijing}$	**1**
β^y_{Fujian}	1.087***	β^p_{Fujian}	1.559**
β^y_{Gansu}	0.784	β^p_{Gansu}	0.833*
$\beta^y_{Guangdong\text{-}Hainan}$	0.579***	$\beta^p_{Guangdong\text{-}Hainan}$	1.255**
$\beta^y_{Guangxi}$	0.758**	$\beta^p_{Guangxi}$	1.645**
$\beta^y_{Guizhou}$	1.366***	$\beta^p_{Guizhou}$	1.314**
β^y_{Hebei}	0.716***	β^p_{Hebei}	1.346**
$\beta^y_{Heilongjiang}$	0.433	$\beta^p_{Heilongjiang}$	1.501**
β^y_{Henan}	0.968***	β^p_{Henan}	1.390**
β^y_{Hubei}	1.219***	β^p_{Hubei}	1.335**
β^y_{Hunan}	0.739***	β^p_{Hunan}	1.517**
$\beta^y_{Inner\ Mongolia}$	0.955***	$\beta^p_{Inner\ Mongolia}$	1.313**
$\beta^y_{Jiangsu}$	0.927***	$\beta^p_{Jiangsu}$	1.230**
$\beta^y_{Jiangxi}$	0.783***	$\beta^p_{Jiangxi}$	1.135**
β^y_{Jilin}	0.909***	β^p_{Jilin}	1.180**
$\beta^y_{Liaoning}$	0.998**	$\beta^p_{Liaoning}$	1.202**
$\beta^y_{Ningxia}$	0.733**	$\beta^p_{Ningxia}$	1.548**
$\beta^y_{Qinghai}$	0.582***	$\beta^p_{Qinghai}$	1.423**
$\beta^y_{Shaanxi}$	1.361***	$\beta^p_{Shaanxi}$	1.254**
$\beta^y_{Shandong}$	0.798***	$\beta^p_{Shandong}$	1.298**
$\beta^y_{Shanghai}$	0.681**	$\beta^p_{Shanghai}$	1.167**
β^y_{Shanxi}	1.361***	β^p_{Shanxi}	1.329**
$\beta^y_{Sichuan\text{-}Chongqing}$	1.533***	$\beta^p_{Sichuan\text{-}Chongqing}$	1.381**
$\beta^y_{Tianjin}$	0.999***	$\beta^p_{Tianjin}$	1.290**
$\beta^y_{Xinjiang}$	0.939***	$\beta^p_{Xinjiang}$	1.451**
β^y_{Yunnan}	1.216***	β^p_{Yunnan}	1.398**
$\beta^y_{Zhejiang}$	1.086***	$\beta^p_{Zhejiang}$	1.374**

Note: Estimates of state space models given by equations (1) and (2), and (3) and (4), respectively. Normalising assumption is $\beta_{Beijing} = 1$. Equation (4) includes an unreported insignificant constant. */**/*** denotes significance at the ten / five / one percent level.

Figure 10: Unobservable component and first principal component for provincial output gaps
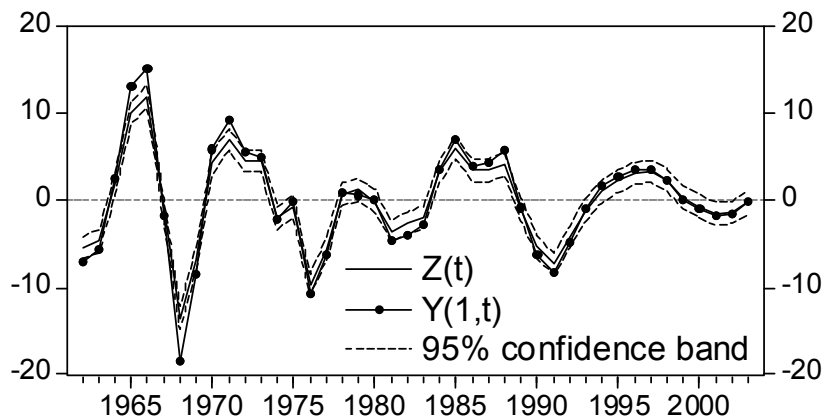
Overall, Section 4 suggests that provincial business cycles are driven by one common component. While the general trend is for regional output gaps to synchronise, a number of mostly north-western provinces have in recent years experienced business cycles different from the rest of China. This raises the question whether price developments in these regions also have become de-coupled from those in other provinces.

5 Inflation synchronisation

We start out our study on the synchronisation of the regional inflation rates in China by showing the 28 time series first presented in Figure 2 together in the upper plot of Figure 11. The lower graph presents the minimum, mean and maximum inflation rate for each year.

Regional inflation rates were often slightly negative up to 1970. After major economic policy reforms started in 1978, administratively set prices were gradually liberalised. Since this in most cases meant an increase in prices, inflation was the consequence. Oppers [15] suggests that the first increase in prices in 1979 to 1981 was triggered by higher wages in the industrial sector and a jump in agricultural prices.[9] To reduce inflation, credit controls were tightened and interest rates increased, which led to a reduction of both

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[9]The following discussion is based on Oppers [15].

inflation and real GDP growth.

Inflation increased again from 1982 onwards, and continued to rise in 1984, when state-owned enterprises were granted larger autonomy in setting wages. Credit controls were tightened in 1986, but financial problems in the state-owned enterprises caused a soon loosening of credit controls. As a consequence, inflation started to rise again that same year. Further liberalisation of prices added to the trend of increasing prices, but tighter credit conditions towards the end of the 1980s again reigned in inflation and reduced GDP growth rates.

At the beginning of the 1990s, agricultural prices were adjusted upwards to market levels and price controls were reduced in the industrial and retail sectors. Inflation started to increase again in 1991. The mean of the regional inflation rates exceeded 14 percent in 1994, and credit growth was again curtailed. Interestingly, Section 4 suggests that while the earlier episodes of monetary tightening had caused recessions, there was no major downturn in economic activity in the mid-1990s. Ha, Fan and Shu [9] argue that this is due to the unification of the renminbi exchange rate, the net effect of which was a devaluation that caused higher export growth. Moreover, foreign direct investment, which by the 1990s had taken on a large scale, supported growth. In 1998, in the aftermath of the Asian financial crisis, inflation turned into deflation. Yu [21] argues that excess capacity and dampened demand after the crisis put downward pressure on prices. At the end of the sample, the mean rate of inflation was 2.8%.

The lower plot of Figure 11 shows that the range of provincial inflation rates has narrowed from 29.2 percentage points at the beginning of the sample to 9.4 percentage points at its end. Thus, inflation rates have apparently become more similar over time. To gain a better sense of this, we show in the top plot Figure 12 the standard deviation for each year and find that the overall trend was downwards. Interestingly, the dispersion of the regional inflation rates increased during the booms in 1988 and 1994. This constitutes a parallel to the results in the literature on inflation dispersion, where high rates of inflation are reported to coincide with a broad variation in price increases of individual goods.

The lower plots in Figure 12 show the first autocorrelation and the kurtosis of the

Figure 11: Range of provincial inflation rates
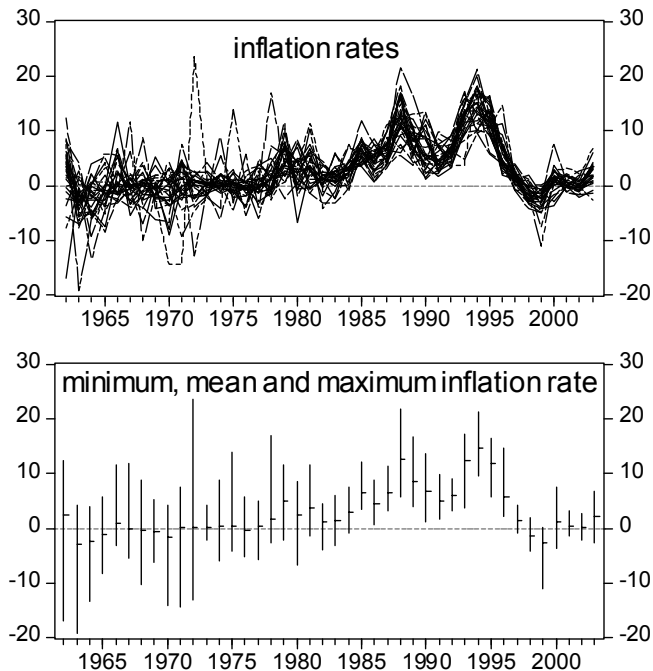
regional inflation rates. While inflation in China has become more autocorrelated over time, it shows much less persistence than the output gap. The kurtosis of the provincial inflation rates has been close to 3 since the end of the 1970s, which suggests that they obey a normal distribution.

5.1 Principal components analysis

It seems plausible that the provincial inflation rates $p_{j,t}$ in China are dominated by one factor, just as appears to be the case of the regional output gaps. To gain a better sense of this, we again perform a principal components analysis. We denote the first two components by $P_{1,t}$ and $P_{2,t}$. The right panel of Table 1 shows their importance as captured by their φ_k^p:s and reports the factor loadings.

We find that the first principal component captures 69.0% of the variance of the 28 regional $p_{j,t}$:s (so that the remaining 27 $P_{k,t}$:s together explain another 31.0%). The second principal component, $P_{2,t}$, reflects 4.7% of the movements in the provincial inflation rates. All provinces significantly contribute to $P_{1,t}$, which suggests that the first principal

Figure 12: Summary statistics of provincial inflation rates
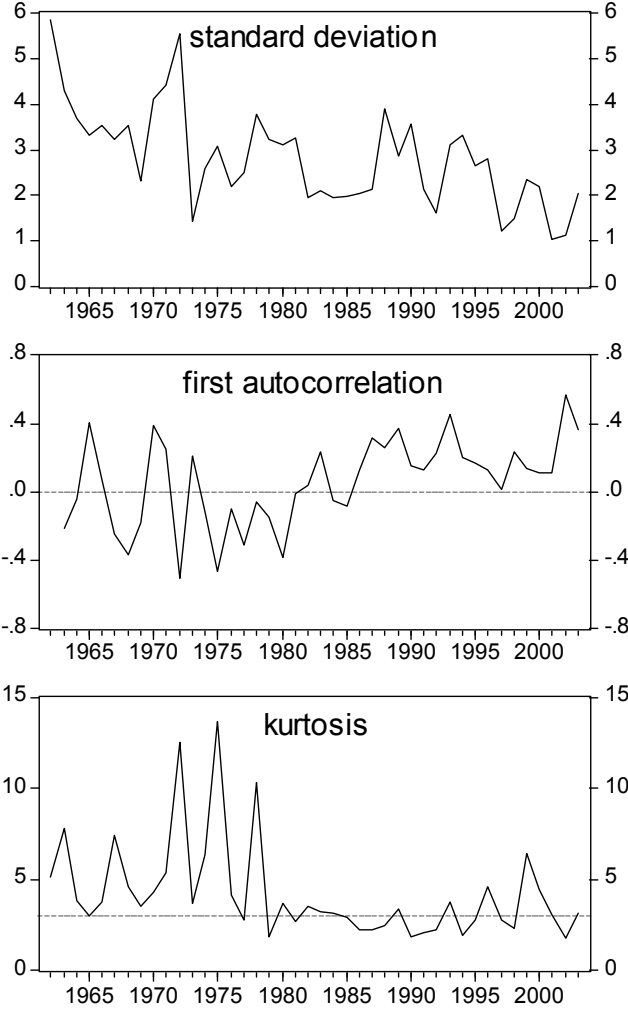
component captures one dominant common factor that impacts on all regional inflation rates.[10] The loading weights range between 0.02 for Gansu to 0.05 for Ningxia. The second principal component seems to capture regional factors of Fujian and Shanghai (all other loading factors are insignificant). We plot $P_{1,t}$ and $P_{2,t}$ in Figure 13 and see that $P_{1,t}$ clearly reflects the episodes of increased inflation discussed above.

Figure 13: First and second principal component of provincial inflation rates
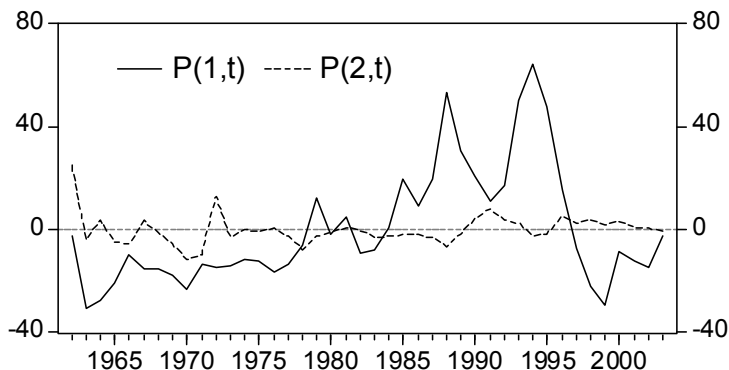
Inspection of $P_{2,t}$ suggests that this component is high at the beginning of the sample and in 1972 but low in 1978 and 1988. Comparing this with the regional inflation data presented in Figure 2, we find that indeed inflation shows peaks in 1962 and 1972 for Shanghai, for which Table 1 reports a positive loading factor. The loading factor for Fujian, by contrast, is negative. It appears that increases in $p_{Fujian,t}$ in 1978 and 1988 account for the decrease in $P_{2,t}$ those years.

To assess whether inflation rates have become increasingly synchronised, we again consider the evolution of φ_1^p over time. In contrast to the results reported for the output gap, Figure 14 shows a steady increase in the importance of $P_{1,t}$. The last data point suggests that for the period 1994 to 2003, 90.9% of the movements in all regional inflation rates are captured by the first principal component. Thus, nation-wide developments appear to dominate the movements in the provincial price indices.
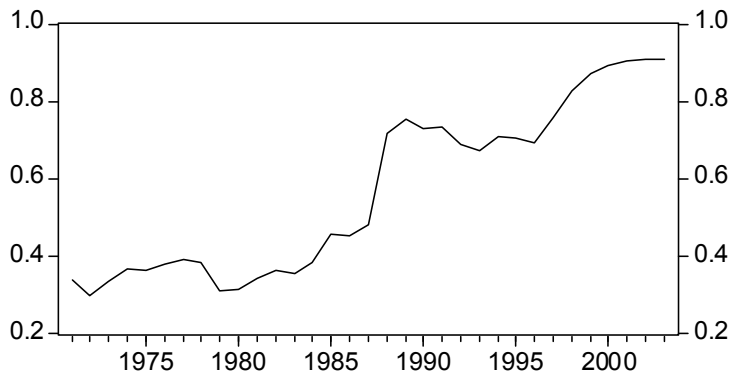
Finally, Figure 15 shows the correlation between the 28 $p_{j,t}$:s and $P_{1,t}$. We find occasional negative correlations in the 1960s and early 1970s in most provinces, but since the

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[10]The correlation between $P_{1,t}$ and the GDP deflator inflation for the country as a whole is 0.95.

Figure 14: Importance of the first principal component of provincial inflation rates

1980s, correlations have tended to be above 0.5 and increasing all over China. This suggests a convergence in the provincial inflation rates towards a common national trend. It thus seems that the synchronisation of regional inflation rates has been more far-reaching than that of provincial business cycles.

5.2 Unobservable components analysis

Since it is our aim below to assess whether Hong Kong's inflation rate has become more closely related to the common component of the inflation rates in the other Chinese provinces, we again perform an unobservable components analysis. Denoting the unobservable inflation component by Q_t, we assume that the regional inflation rates are given by

$$p_{j,t} = \beta_j^p Q_t + v_{j,t}, \tag{3}$$

where again the variability of the shocks and the reaction to Q_t may differ between provinces. Since $P_{1,t}$ follows an AR(1), we assume that

$$Q_t = \alpha_0 + \alpha_p Q_{t-1} + w_t. \tag{4}$$

The right panel in Table 2 shows the estimation output. We find significant reactions to Q_t for all provinces. The weakest response is estimated for Gansu, while prices in Fujian seem to react most strongly to a change in the unobserved common inflation rate.

Figure 16 indicates that, while the normalised $P_{1,t}$ is close to the smoothed estimate

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Figure 15: Correlations between provincial inflation rates and first principal component
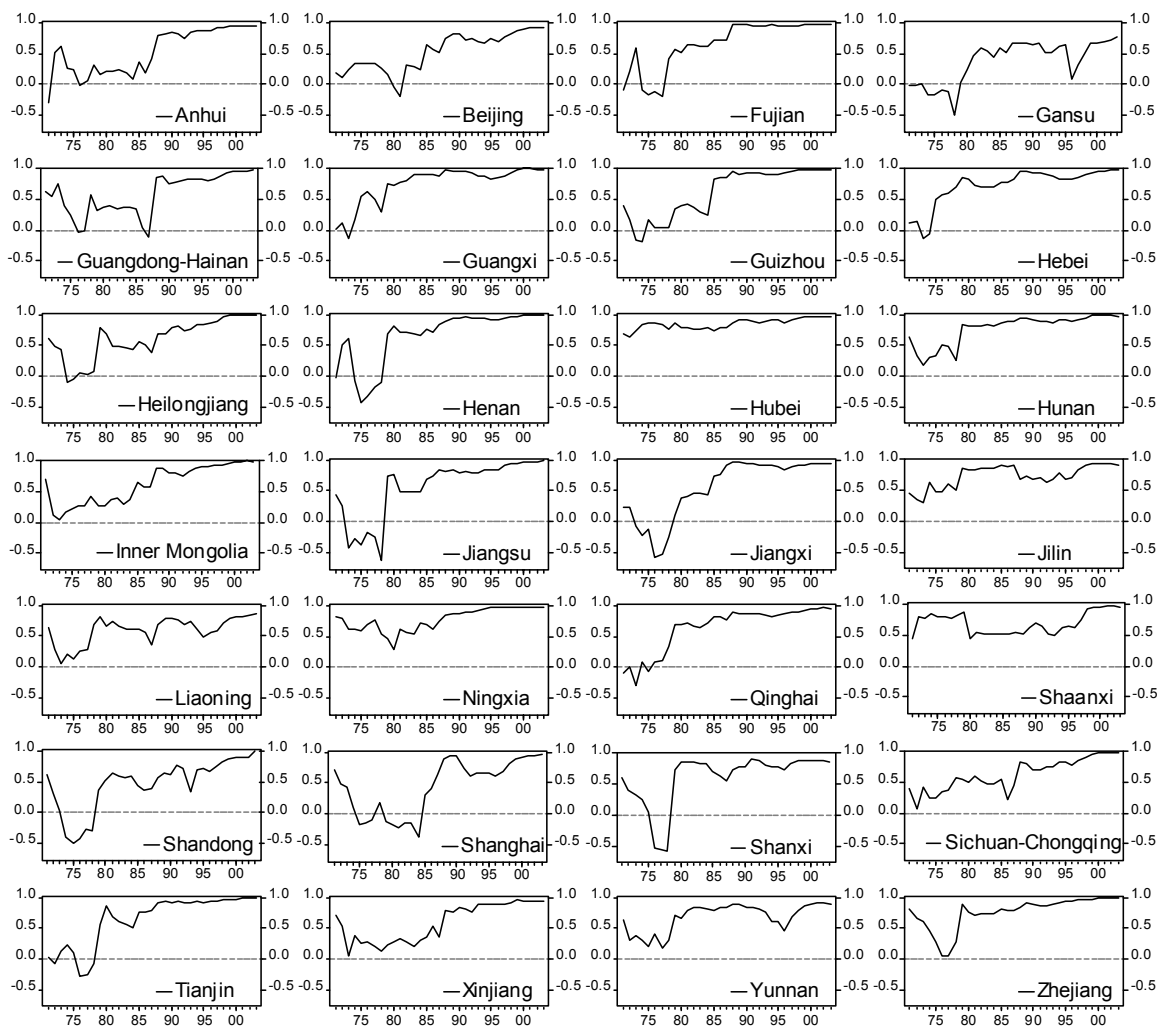
of Q_t throughout the sample, it often lies outside the confidence band.[11] The deviations are strongest during the peaks of inflation in 1988 and 1994.

Figure 16: Unobservable component and first principal component
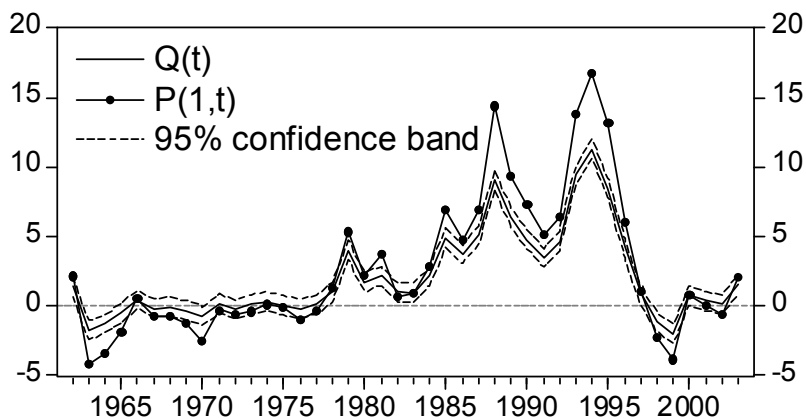
6   Synchronisation between Hong Kong and Mainland China

Hong Kong became a Special Administrative Region of the People's Republic of China in 1997. While the "one country, two systems" strategy was adopted for the initial fifty years, anecdotal evidence suggests that Hong Kong has become increasingly integrated with the Mainland economy. We here attempt to provide formal evidence on the integration of the two economies by assessing whether business cycles and inflation rates have become synchronised.

Figure 17 shows the Hong Kong output gap and inflation together with the provincial data from Mainland China. It appears that both series have become more closely linked to their Mainland counterparts towards the end of the sample period. Interestingly, economic activity in Hong Kong also seems to have followed developments across the boundary in the 1960s and early 1970s. A second noteworthy episode is the Asian financial crisis,

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[11]We normalise $P_{1,t}$ such that it has the same mean and standard deviation as the average provincial inflation rate.

during which pressure for the Hong Kong dollar to be devalued was high. The consequent increase in interest rates led to an economic contraction in 1998 and 1999. The output gaps of the other Chinese regions do not show this pronounced downturn. We also clearly see that Hong Kong's recovery in 2000 was not a reflection of events in Mainland China.

Figure 17: Output gaps and inflation rates in Hong Kong and mainland China
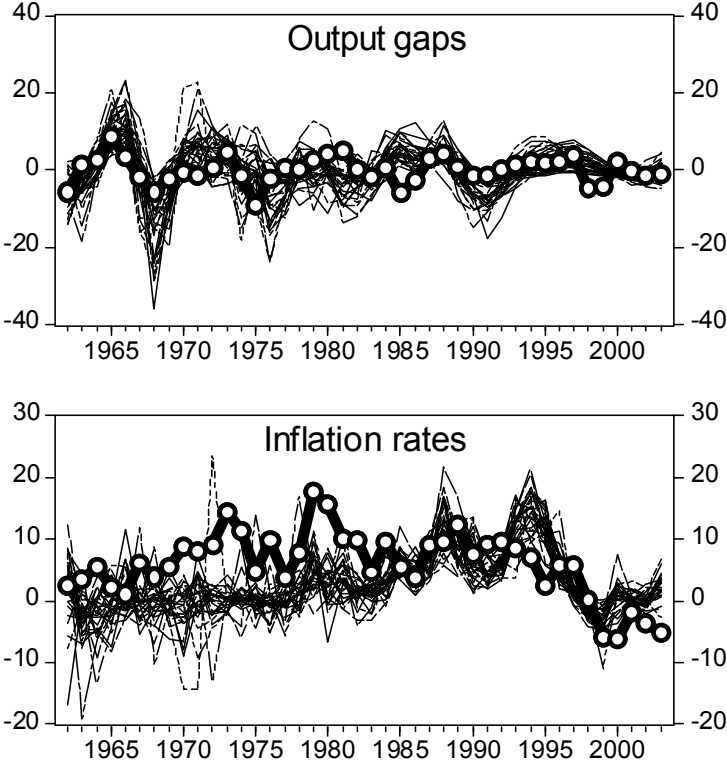
Inflation rates in Hong Kong and Mainland China do not appear to be as closely linked as the output gaps. Before the introduction of the currency board in 1983, inflation in Hong Kong tended to be higher than in the Mainland, but thereafter it was as a rule lower. The loose link between inflation in these two economies is apparent in Figure 18, which plots $y_{HK,t}$ and $p_{HK,t}$ together with the estimates of the unobservable components Z_t and Q_t. The lower plot indicates that $p_{HK,t}$ was above the common inflation component of the Chinese provinces up to the middle of the 1980s and below Q_t for several years in the 1990s and after 2000. The weak link between inflation in Hong Kong and Mainland China is also evidenced by the comparatively low correlations of under 0.60 between $p_{HK,t}$ and $P_{1,t}$ shown in the lower plot of Figure 19 (we again use a ten-year time rolling time

window for the calculation of the correlations).

Figure 18: Hong Kong data and unobservable components for mainland China
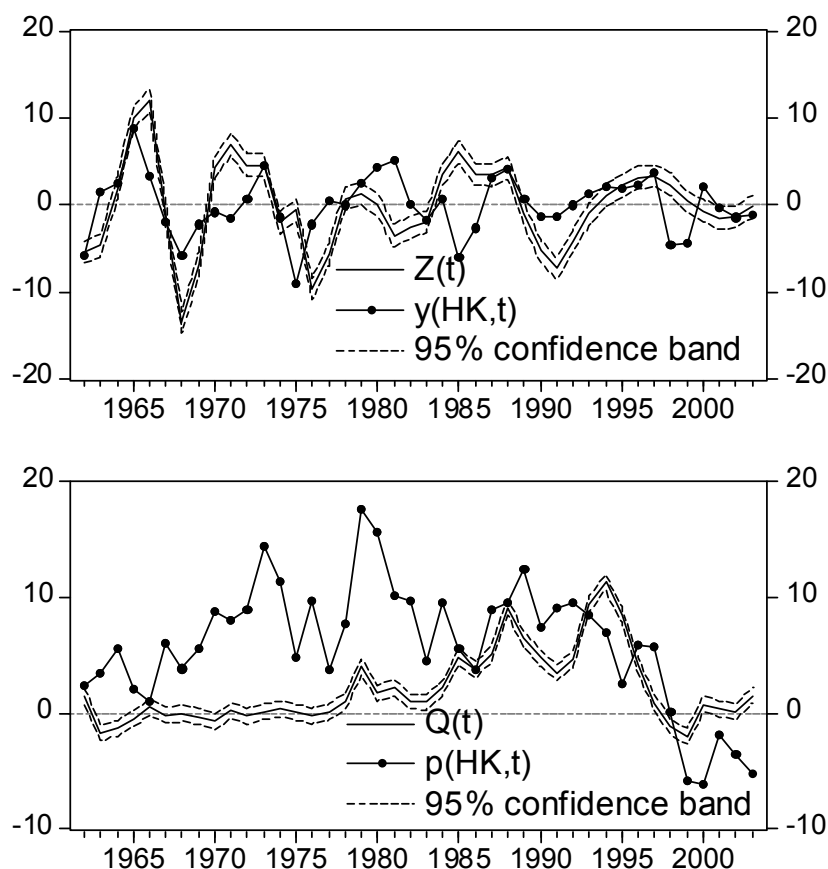
Hong Kong's output gap lies frequently within the 95% confidence band of $Z_{1,t}$ in Figure 18 from the end of the 1980s onwards, but the Asian financial crisis causes deviations from 1998 to 2000. The upper plot of Figure 19 shows the correlation between $y_{HK,t}$ and $Y_{1,t}$ and suggests that the Hong Kong business cycle has become more integrated with economic activity in the Mainland from the mid-1980s onwards. In fact, the correlation between $y_{HK,t}$ and $Y_{1,t}$ was for the time span 1988 to 1997 close to unity and thus above the average correlation of 0.84 between the 28 Mainland $y_{j,t}$:s and $Y_{1,t}$.

Overall, the Hong Kong business cycle seems to have become synchronised with that in Mainland China. Thus, the integration of the two economies appears well under way. As regards the differences in the paths of inflation in Hong Kong and Mainland China, they are likely due to the monetary policy strategy used in the two economies. While

Figure 19: Correlation between Hong Kong data and mainland first principal components
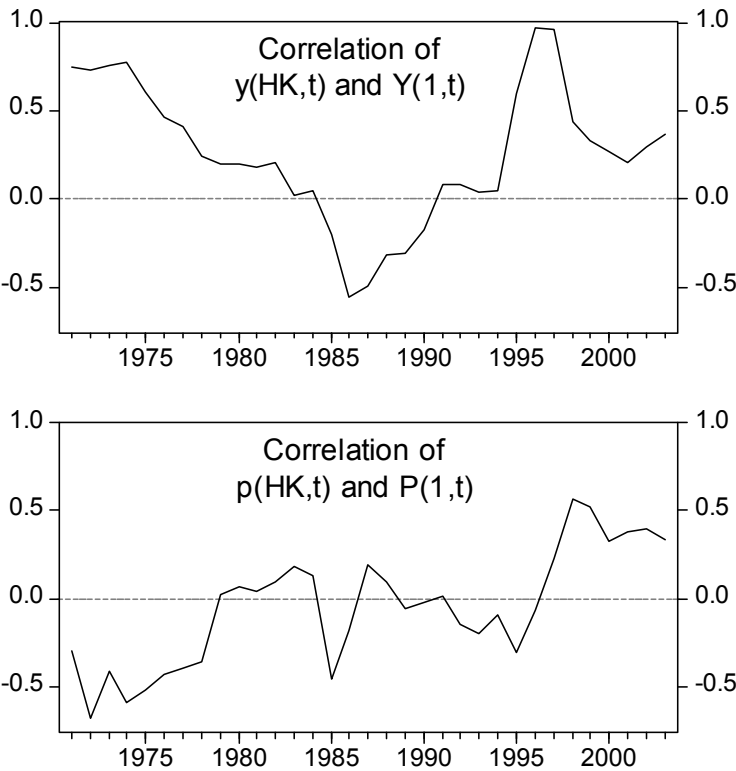
both the Hong Kong dollar and the Chinese yuan are fixed against the US dollar, Hong Kong allows for free capital flows and thus lets the level of interest rate be determined by the US federal funds rate and risk premia. As a consequence, the monetary policy in Hong Kong does not have an instrument to impact on inflation developments. Mainland China, by contrast, enforces capital controls and thus is free to choose the level of its interest rates. Since the Chinese authorities use monetary policy to impact on inflation, it is not surprising that the path of prices differs from that in Hong Kong.

7   Conclusions

In sum, it appears that within Mainland China, there has been a synchronisation of both business and inflation cycles. While economic activity in the different provinces started to show a strong common component from mid-1980s onwards, a similar development began for inflation already in the 1960s, and by 2003, inflation rates throughout China seem to be synchronised. It is notable that, in spite of an overall convergence of the regional business cycles, economic activity in a number of provinces in the north-west of China displays movements that are not closely related to developments in the rest of the country.

As regards Hong Kong, we find that the business cycle seems to have synchronised with that of the Mainland, while inflation developments appear largely independent. It seems probable that this is due to differences in the monetary policy regimes in use in Hong Kong and the Mainland. In particular, the higher mobility of international capital exposes prices in Hong Kong to more and stronger exogenous shocks than those in the Mainland.

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