Output Gaps and Inflation in Mainland China

Stefan Gerlach
Hong Kong Monetary Authority,
Hong Kong Institute for Monetary Research and the CEPR

Wensheng Peng
Hong Kong Monetary Authority*

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Abstract

We estimate output gaps using three methods for Mainland China on annual data spanning 1978-2003. The estimates are similar and appear to co-move with inflation. Standard Phillips curves, however, do not fit the data well. This may reflect the omission of some important variable(s) such as the effect of price deregulation, trade liberalisation and/or changes in the exchange rate regime. We reestimate Phillips curves assuming that there is an unobserved variable that follows an AR(2) process. The modified model fits the data much better and accounts for some of the surprising features of the simple Phillips curve estimates.

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* Corresponding author: Wensheng Peng, HKMA, 55th Floor, Two International Finance Centre, 8 Finance Street, Central, Hong Kong, tel. 2878 1282, fax. 2878 1897, email: Wensheng_Peng@hkma.gov.hk.

1. Introduction

Since the economic reform programme started in the late 1970s, the economy of Mainland China (the "Mainland" hereafter) has experienced a number of episodes of pronounced economic growth, interrupted by generally sharp but short-lived periods of slowdown. These cyclical swings in the economy have been associated with large movements in inflation. Most recently, the deceleration of economic growth in the period 1995-2002 led to a decline of inflation and, indeed, to the development of deflationary pressures. Specifically, the retail price index (RPI) declined at an average rate of 1.2% per annum in 1997-2003, compared with an average rise of 9.7% in 1979-96, while annual real GDP growth slowed to 7.7% from 9.4% during the same periods.[1] Growth subsequently rebounded, reaching a year-on-year rate of over 9% for 2003. Inflation also rose, to a year-on-year rate of about 3% in early 2004.

These developments have led analysts to wonder whether the Mainland economy has entered an overheating phase and whether and to what extent macroeconomic policies should be tightened to stabilise the economy. The increase in inflation also raises the issues of the nature of the inflation process in the Mainland and, in particular, whether traditional Phillips-curve models, in which inflation is determined by past inflation and the output gap, are useful for analysing inflation in the Mainland. This is the central question we focus on in this paper.

The paper is structured as follows. In Section 2 we briefly review the limited literature on the role of the output gap in the Mainland. In Section 3 we review the behaviour of inflation, using four different price indices. We argue that while there are differences in the behaviour over time of the various measures of inflation, these are dominated by a few cyclical peaks. In Section 4 we construct measures of the output gap using three different statistical approaches. We show that the resulting estimates are very similar, which casts some doubt on the proposition that it is difficult to estimate the output gap in the Mainland because of large structural changes in the economy. Section 5 contains the econometric model and our estimates. We first show that

[1] The consumer price index (CPI), which is available only from 1985 onwards, shows a slight rise of 0.2% per year in 1997-2002 with falls in 1998-99 and 2002, compared with much higher rates of inflation in the earlier years.

traditional Phillips curves do not fit the data well and that a generalised Phillips curve that imposes less structure on the dynamic adjustments fits the data better but leads to parameter estimates that are difficult to interpret. To explore whether these results can be explained by omitted variables, we develop a modified Phillips-curve model which includes an unobserved variable that obeys a second-order autoregressive process. We estimate the model and find that it can explain the parameter estimates of the generalised Phillips curve. Section 6 concludes.

2. Output gaps and inflation in the Mainland

There has been a number of studies on estimating potential output in the Mainland, including Chow (1993), Borensztein and Ostry (1996), Hu and Khan (1996), Woo (1998), Chow and Li (2002) and Heytens and Zebregs (2003). However, the link between inflation and the output gap remains under-studied.[2] Oppers (1997) employs a Phillips-curve model and finds that inflationary episodes have generally been associated with increases in aggregate demand. He argues that the factors behind the upswings, and the relative importance of the components of aggregate demand, differed across cycles. In particular, the upturn in the first part of the 1990s was supported mainly by a surge in investment spending which raised production capacity and helped achieve a soft landing of the economy in the sense that a marked disinflation was achieved with relatively moderate slowdown in growth. Imai (1997) studies short-run output-inflation tradeoffs using a small macroeconomic model and finds that large fluctuations in fixed investment were the main force driving the rate of inflation in the reform period. More recently, Woo (2003) examines the experience of the period 1997-2002 and argues that inadequate financial intermediation contributed to a slower expansion of aggregate demand than aggregate supply, imparting a deflationary tendency to the economy. However, the paper does not include a formal study of the impact of the output gap on inflation.

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[2] Another strand of research on inflation in China focuses on monetary factors. In particular, Chen (1997) estimates a long-run demand function for money and examines its implications for controling inflation. Hasan (1999) finds a bi-directional or feedback relationship between inflation and money growth.

Several factors explain the paucity of studies on the relationship between inflation and the output gap in the Mainland. First, potential output is difficult to estimate, and measures of the output gap are therefore likely to be poor, reducing their information content for future inflation. The difficulty is in part related to the availability and reliability of statistics.[3] It also reflects the tremendous structural changes in the economy in recent decades, as the Mainland has gone through a period associated with a gradual opening of the economy, industrialisation, and transition from a centrally planned to a market-based economy. Second, the Mainland has experienced a number of economic shocks and disturbances, some of which are related to policy measures to liberalise the economy. Thus, deregulation and liberalisation are likely to lead initially to sharp increases in inflation as prices rise towards market clearing levels, but to price declines over time as the greater scope for market forces leads to lower profit margins. The difficulty of finding empirical proxies capturing such influences complicates the study of the inflation process.

While these considerations are certainly important, they apply to all economies, although potentially to varying degrees. Their significance is thus an important, but unsettled, issue. For example, do they preclude any meaningful econometric study of the relationship between inflation and the output gap in the Mainland? If not, are there ways to specify the Phillips curve that increase its ability to account for movements in inflation?

This paper presents empirical work that bears on these two questions. First, it considers three different estimates of the output gap in the Mainland and shows that these are strikingly similar. This finding casts doubt on the view that it is more difficult to estimate the output gap in the Mainland than elsewhere because of the sharp structural changes in the economy since the process of economic reform started in the late 1970s. Next, it proposes an empirical Phillips-curve model that is appropriate in the case of an omitted, serially correlated variable (or a linear combination of variables). This framework is particularly useful in the case of the

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[3] There is considerable debate about the accuracy of China's official output statistics, and data required for estimating potential output using the production function approach such as capital accumulation and labour force growth are subject to significant measurement errors. Chow and Li (2002) discuss data issues in estimating a production function for China.

Mainland, which has been subject to price deregulation, import tariff reduction and foreign exchange market reforms. These factors are difficult to quantify but have indisputably impacted on inflation in the past two decades. By treating them as an unobserved variable in the econometric analysis, it becomes possible to incorporate them in the Phillips-curve model despite the lack of data on these factors.

3. Inflation

We start the analysis by considering the measurement of inflation. We have data on four price indices: the GDP deflator from 1978; a consumer price index (CPI) from 1985; a retail price index (RPI) from 1978; and a producer price index (PPI) from 1979.[4] Figure 1 shows inflation calculated using these four measures of prices. The graph indicates that while most of the fluctuations in inflation are due to a few, sharp cyclical peaks, there have occasionally been marked differences between the different inflation rates. Table 1 contains estimated correlation coefficients as a more formal measure of the similarities of the different time series. These coefficients are uniformly high, ranging from 0.92 to almost unity.

Much attention has been attached to the decline in inflation between 1995 and 2000. Indeed, this period of sharp disinflation was followed by episodes of declines in price indices which took hold in late 1997 and early 1998, and raised concerns about deflation (defined as a period of sustained falls in prices). Subsequently, the rate of price change remained close to zero but started to rise in the later part of 2003. As economic growth accelerated, the CPI rose by about 3% by the end of 2003 compared with the same period of the previous year, while the PPI recorded an even higher rate of growth. While the CPI inflation rate remained moderate, the quick turn around from price declines to increases, coupled with sharp growth in broad money and bank credit have raised concerns that the economy may be overheating. Assessing whether this is the case is complicated in part by the fact that most of the increase in the CPI was related to prices of agricultural products, and that prices of many manufactured goods continued to decline or recorded only moderate rises. Thus, an analysis of the aggregate demand relative to the supply potential of the economy is useful.

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[4] The data are from CEIC.

4. Output gaps

A standard way of assessing inflation pressures is to consider the output gap, that is, the difference between actual and potential output. There are two broad approaches to estimating potential output and thus the output gap. One is the production function approach, which makes use of information regarding the sources of growth, that is, factor accumulation and the state of total factor productivity (see Hu and Khan (1996), Chow and Li (1999) and Heytens and Zebregs (2003)). A main advantage of this approach is that it provides an understanding of the sources of growth. Such information is of independent value as it may help guide policies to raise productivity. The main disadvantage arises from the need for high quality data on the capital stock and the labour force. In many economies, in particular in the Mainland, such data are subject to considerable measurement errors and may therefore lack credibility.[5]

Another approach is to identify the trend in real GDP with potential output and to use time series techniques to estimate it. A frequently used tool is the Hodrick-Prescott (HP) filter, which decomposes actual output into a long-run trend and cyclical components. This is a statistical method that does not use any information regarding the determinants of each of the components, but provides a useful approximation of potential output growth. More refined approaches include the unobservable-components (UC) techniques proposed by Watson (1986) and Clark (1989) for US data. Gerlach and Yiu (2004) estimate output gaps for eight Asian economies using four different time series methods and conclude that both the HP filter and the UC approach generate plausible estimates of the output gap. However, they do not provide estimates for the Mainland.

While the time series approach is easy to implement, it suffers from the drawback that it provides no economic understanding of the sources of growth. Thus, it is arguably best seen as a complement to the more rigorous production function approach. With this caveat in mind, we employ it below to construct three measures of the output gap. First, we use the Hodrick-Prescott filter to construct a measure of potential output

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[5] Chow (1993) and Chow and Li (1999) provide detailed discussions about measurement issues. Most of the other studies such as Heytens and Zebregs (2003) use data on the capital stock constructed by Chow and his co-author.

from the logarithm of real GDP.[6] Second, we also regress the logarithm of real GDP on a cubic polynomial in time and use the residuals as a measure of the output gap. Third, we estimate the output gap using the unobservable components model employed by Gerlach and Yiu (2004). One benefit with this model is that it provides an explicit estimate of the degree of uncertainty of the resulting measure of the output gap. Since the first two methods are straightforward and familiar to most macroeconomists, we do not discuss them further but instead briefly review the unobservable components approach which is less well known.

4.1 Unobservable components estimates of output gaps

Letting y_t, y_t^p and z_t denote the logarithms of actual and potential output and the output gap, we have by definition:

(1) $$y_t \equiv y_t^p + z_t,$$

which says that actual output equals the sum of potential output and the output gap. The task we face is to decompose the observed time series on real GDP into these two components. To do so, we need to make assumptions about the time-series behaviour of these factors. Potential output is assumed to follow a random walk with drift:

(2) $$y_t^p = \mu_{t-1} + y_{t-1}^p + \varepsilon_t^y.$$

Equation (2) states that the rate of growth of potential output depends on temporary shocks, which are captured by $\varepsilon_t^y \sim N(0, \sigma_y^2)$, and more persistent growth factors, μ_t. We allow μ_t to vary over the sample period as suggested by Clark (1989):

(3) $$\mu_t = \mu_{t-1} + \varepsilon_t^\mu,$$

where $\varepsilon_t^\mu \sim N(0, \sigma_\mu^2)$ denotes a permanent shock to the rate of growth of potential. Finally, the output gap, z_t, is assumed to obey an AR(2) process:

(4) $$z_t = \phi_1 z_{t-1} + \phi_2 z_{t-2} + \varepsilon_t^z,$$

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6 In doing so we set the smoothing parameter $\lambda = 100$ which is the default for annual data in EViews.

where $\varepsilon_t^z \sim N(0, \sigma_z^2)$.

The model – which consists of the autoregressive parameters for the output gap (ϕ_1 and ϕ_2) and the three variances (σ_μ^2, σ_y^2 and σ_z^2) – can be estimated by sequentially evaluating the likelihood function using Kalman filtering.[7] The estimation results are provided in Table 2. Two findings are of interest. First, the autoregressive coefficients for the gap are highly significant and obey $\phi_1 > 1$, $\phi_2 < 0$, and $0 < \phi_1 + \phi_2 < 1$. This implies that a shock to the output gap leads to "hump-shaped" responses in the sense that the gap first grows over time before returning to zero in an oscillatory manner. Second, σ_y^2 is estimated to equal zero, implying that there are no temporary shocks to the growth rate of potential.

Before discussing our estimates of the output gaps, we plot in Figure 2 the growth rate of potential, μ_{t-1}, together with a 95 percent confidence band.[8] The figure shows that that μ_t declined over time, from (a point estimate of) 9.6% in 1978 to about 8.8% in 2003. However, the confidence band is quite broad, so the growth rate of potential is not precisely estimated. Note also that the confidence bands are larger at the end and the beginning of the sample. This reflects the fact that in the absence of data, relatively little is known about the μ_t towards the ends of the sample.

4.2 Comparing the output gaps

In Figure 3 we plot the output gap resulting from the unobservable-components model (UCGAP) together with a 95 percent confidence band. The confidence band is quite broad, which suggests that it is difficult to know the state of the business cycle, even ex post. That does not, however, indicate that this measure is "worse" than other estimates of the gap. All measures of the output gap should be interpreted as point estimates and ought to be provided with confidence bands. Since these are rarely computed, one naturally tends to overestimate the precision by which the output gap

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[7] We are grateful to Matthew Yiu for estimating the model.

[8] We use the full data set to construct an estimate of the growth rate of potential. See Harvey (1993) for a discussion of Kalman filtering.

has been estimated. One major advantage of the UC approach is that it renders explicit the uncertainty pertaining to calculations of the gap.

For comparison purposes, in Figure 4 we plot both the output gap as measured by the HP filter (HPGAP) and constructed using the residuals from a regression of real output on a polynomial in time (TGAP). It is striking how similar these estimated gaps are. In fact, the HPGAP and the TGAP are typically well within the 95 percent confidence band for the UCGAP. The correlation coefficients for the different measures of the gaps in Table 2 range from 0.89 to 0.98. The finding that different methods give rise to strikingly similar estimates of the output gap suggests that these alternative measures will have roughly the same explanatory power for inflation. The similarity of the estimates moreover calls into question the common view that it is difficult to estimate the output gap in the Mainland.

As a prelude to the econometric work below, it is interesting to note that the estimated output gaps evolve over time in line with movements of inflation and other indicators of macroeconomic conditions. Specifically, the three downturns in economic activity in 1981-83, 1989-91, and 1998-2003 were accompanied by sharp falls in inflation. Furthermore, the upturns around the mid-1980s and the early 1990s saw a marked acceleration in inflation rates. The estimated cycles in the output gap are broadly in line with estimates presented in other studies that use the production function approach, such as Heytens and Zebregs (2003). The developments in the recent downturn seem to suggest a decline of the sacrifice ratio, as sharper disinflation was achieved with a smaller negative output gap than in the previous cycles. This may reflect a number of factors, including a strong US dollar, to which the renminbi is de facto pegged, and increased flexibility in the Mainland economy due to structural reforms in the earlier years.

5. The output gap and inflation

5.1 Preliminary econometric work

Next we explore the information content of the different measures of the output gap. Since applied econometric work on the determination of inflation is frequently based on backward-looking Phillips curves, as a preliminary we estimate a traditional Phillips curve of the form:

$$(6) \qquad \pi_t = \alpha + \beta_1 \pi_{t-1} + \delta_0 g_t + \varepsilon_t$$

where π_t denotes inflation, g_t the output gap and ε_t a regression residual. The parameter of interest is δ_0, which captures the impact of the output gap on inflation. Since we have data on four price indices and three measures of the output gap, we could estimate twelve versions of equation (6). To reduce the dimensions of the empirical work, we only estimate equations for inflation as measured by the RPI and the GDP deflator since these are available from 1978 onwards, when the GDP data starts. Furthermore, we focus on the UCGAP, which has the advantage that it is possible to estimate a confidence band for it, and the HPGAP, since this is the approach to constructing output gaps adopted in much applied econometric work. This reduces the number of combinations of price indices and output gaps to four.

In Table 4 we present the results. The results in the first column of Table 4 indicate that, depending on the exact choice of price index and measure of the output gap, the parameter on lagged inflation is about 0.6-0.7 and highly significant. The parameter on the output gap, by contrast, is about 0.2 and insignificant when the deflator is used, but about 0.5-0.6 and significant at the 10% level when the RPI is used. The DW statistics are low, about 1.2, and unreported Q-tests show that there is statistically significant correlation of the residuals, implying that this simple model fails to capture the dynamics of the data.

We therefore re-estimate a more general Phillips curve that allows for a second lag of inflation and the output gap:

$$(7) \qquad \pi_t = \alpha + \beta_1 \pi_{t-1} + \beta_2 \pi_{t-2} + \delta_0 g_t + \delta_1 g_{t-1} + \varepsilon_t$$

As can be seen in column 2 of Table 4, this specification fits the data much better. The estimates β_1 and δ_0 both rise in numerical value and are highly significant, as are the additional lags. Furthermore, the adjusted R-squared rises quite sharply and the DW statistics approach 2, indicating a reduction in the degree of serial correlation in the residuals.

One striking aspect of these results is that the estimates β_2 and δ_1 both have a *negative* sign. Indeed, the data appear to suggest that it is the change in the output gap, $\Delta g_t = g_t - g_{t-1}$, that drives inflation. While (unreported) diagnostic tests suggest that the model fits the data well, these findings are not easily interpretable. One possibility is that these surprising results arise because economically important variables have incorrectly been omitted from the analysis. Before exploring this hypothesis, we add an additional lag of both inflation and the output gap and estimate:

(8) $$\pi_t = \alpha + \beta_1\pi_{t-1} + \beta_2\pi_{t-2} + \beta_3\pi_{t-3} + \delta_0 g_t + \delta_1 g_{t-1} + \delta_2 g_{t-2} + \varepsilon_t$$

The results in column 3 of Table 4 are clearly worse in the sense that the adjusted R-squareds are lower. Furthermore, with the exception of β_1, the parameters are all insignificant, which probably reflects multicollinearity arising from the fact that the regressors display considerable serial correlation. The parameters have the same patterns of signs as in the case of equation 7.

Overall, this analysis leads us to conclude that equation (8) overfits the data and that equation (7), which fits the data much better, leads to parameter estimates that are difficult to interpret.

5.2 A model of inflation in the Mainland

In this section, we explore whether omitted variables may explain the fact that β_2 and δ_1 are significant but have negative signs in equation (7). Such omitted variables could capture one or a number of factors, for instance, the effects of external shocks, price deregulation or expected inflation. To include them into the analysis, consider the following version of equation (6):

(9) $$\pi_t = \alpha + \beta\pi_{t-1} + \delta g_t + \gamma z_t + \varepsilon_t$$

where z_t denotes an omitted variable (or a linear combination of omitted variables) and where we have deleted the subscripts on β and δ since there is only one of each. Of course, equation (8) could be estimated directly if we had data on z_t or if we could construct a plausible proxy for it. However, here we assume that this is not feasible. Suppose, however, that we are willing to assume the following time series representation for the omitted variable:

(10) $z_t = \theta_1 z_{t-1} + \theta_2 z_{t-2} + v_t$

Thus, we assume that z_t follows an AR(2) process. Next the issue arises whether we can use equation (10) to obviate the need for data on z_t to estimate equation (9). Combining equations (9) and (10) and multiplying both sides by $(1-\theta_1 L - \theta_2 L^2)$ we have that:

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\begin{aligned}
\pi_t - \theta_1\pi_{t-1} - \theta_2\pi_{t-2} &= \alpha(1-\theta_1-\theta_2) + \beta(\pi_{t-1} - \theta_1\pi_{t-2} - \theta_2\pi_{t-3}) \\
&+ \delta(g_t - \theta_1 g_{t-1} - \theta_2 g_{t-2}) + \gamma(z_t - \theta_1 z_{t-1} - \theta_2 z_{t-2}) \\
&+ \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2}
\end{aligned} \quad (11)
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Defining $\tilde{\alpha} = \alpha(1-\theta_1-\theta_2)$ and $\phi_t = \gamma v_t + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2}$, we can then write that:

(12) $\pi_t = \tilde{\alpha} + (\beta+\theta_1)\pi_{t-1} + (\theta_2 - \beta\theta_1)\pi_{t-2} - \beta\theta_2\pi_{t-3} + \delta(g_t - \theta_1 g_{t-1} - \theta_2 g_{t-2}) + \phi_t$

or more compactly

(12') $\pi_t = \alpha^* + \beta_1^*\pi_{t-1} + \beta_2^*\pi_{t-2} + \beta_3^*\pi_{t-3} + \delta_0^* g_t + \delta_1^* g_{t-1} + \delta_2^* g_{t-2} + \phi_t^*$

where $\alpha^* = \tilde{\alpha}$, $\beta_1^* = \beta + \theta_1$, $\beta_2^* = \theta_2 - \beta\theta_1$, $\beta_3^* = -\beta\theta_2$, $\delta_0^* = \delta$, $\delta_1^* = -\delta\theta_1$, $\delta_2^* = -\delta\theta_2$ and $\phi_t^* = \gamma v_t + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2}$.

Two aspects of equation (12) are of interest. First, suppose that the unobserved variable is highly autocorrelated, so that θ_1 is close to unity and that θ_2 is close to zero. If so, the omission of z_t will spuriously lead to the impression that it is the change in the output gap that impacts on inflation. Moreover, the specification error could also lead the rate of inflation at t-2 spuriously to have a negative coefficient. These results suggest that the omission of a relevant, autocorrelated variable might be able to explain the surprising features of the estimates of equation (7) discussed above. Second, note that $E(\phi_t, \phi_{t-1}) = -\theta_1\sigma_\varepsilon^2$ and that $E(\phi_t, \phi_{t-2}) = -\theta_2\sigma_\varepsilon^2$, that is, the residuals should obey negative second-order serial correlation. Of course, whether they do so in practice depends on the relative variances of the structural shocks (v_t and ε_t) and the parameters γ, θ_1 and θ_{21}. This is thus an empirical question that we return to below.

5.3 Estimates

Next we estimate the model. Since the results in Table 4 indicate that the HPGAP fits the data best and since the adjusted R-squareds are somewhat higher when inflation is measured by the deflator rather than the RPI, in what follows we use these variables in the interest of brevity.[9]

Column 1 in Table 5 reports estimates of the parameters in equation (12), using non-linear least squares. First, the estimate of θ_1 is 1.3 and is highly significant. By contrast, θ_2 is estimated to be –0.4, but is not significant at the 10% level.[10] The impact of the output gap on inflation, which is captured by δ, is somewhat greater than unity and thus larger than before, and is significant at the 10% level. The impact of the lagged inflation rate, captured by β, is negative but insignificant. This finding is perhaps somewhat surprising and we discuss it further below.

Before doing so, we assume that $\beta = 0$ and reestimate the model. The results in column 2 of the same table are much better. In particular, θ_1 and θ_2 are both significant at the 5% level and are estimated to be 1.2 and –0.5, respectively. The intercept, α, and the parameter on the output gap, δ, are both positive and significant. Furthermore, the equation appears to fit the data quite well, as evidenced by a Q-test for second-order autocorrelation of the residuals (p = 85.5%), a Jarque-Bera test for normality (p = 76.7%) and a White test for heteroscedasticity (p = 55.0%). Finally, a likelihood ratio test of the restrictions implicitly imposed by equation (12) on (12') yields p = 43.3%, which implies that the restrictions are not rejected by the data. Thus, the hypothesis that the rather surprising sign patterns of the parameters arising from estimates of equations (7) stem from an omitted variable that obeys an AR(2)

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9 The results are quite similar if the other price indices and measures of the output gap are used.

10 Analogously to the case of the output gap, these parameter estimates imply that the omitted variable follows a humped-shaped pattern in response to v-shocks.

specification seems compatible with the data. It should be emphasised that the model is quite parsimonious in that it only involves four parameters (α, δ, θ_1 and θ_2). The fact that it matches the data is thus supportive of the omitted-variables hypothesis.

These results warrant two comments. First, the finding that $\beta = 0$, which implies that past inflation does not impact on current inflation, stands in contrast with the existing literature on Phillips curves, which typically finds that $\beta \approx 1$. However, while this finding may be surprising, it should be kept in mind that little is known about the omitted variable and that there is no reason why it could not be closely related to inflation. (In particular, it may reflect inflation expectations.) Thus, the finding that past inflation is insignificant does not, on its own, invalidate the model. Second, the importance of the omitted variable, coupled by the fact that it is unidentified, might suggest that the model couldn't be used to evaluate inflation pressures and forecast future inflation. That conclusion, however, is unwarranted. The presence of the omitted variable merely imposes a tight relationship between current and past inflation rates and output gap, which are observed. Thus, the model can be used in the same way as any standard Phillips curve model. The benefit of the omitted variables approach is that it provides an explanation for why the lagged output gap and the twice-lagged inflation rate enter with negative signs in the unrestricted Phillips curve in equation (7). Furthermore, this approach appears to provide a better, or at least a larger, estimate of δ.

6. Conclusions

This paper studies the relationship between inflation and the output gap in the Mainland of China in the 1982-2003 period. A number of time series techniques are employed to estimate potential output and to construct estimates of the output gap. These estimates are strikingly similar, and movements in them appear associated with swings of inflation. They are also broadly similar to estimates in the literature that make use of a production function approach.

We then turn to the question whether the determination of inflation in the Mainland can be understood using a Phillips-curve framework. The estimates suggest that a simple application of the Phillips curve does not fit data well and that this may reflect an omission of some important variables. Given the tremendous structural change and policy shifts in the Mainland in the estimation period, this hypothesis appears plausible. In particular, price deregulation, trade liberalisation and changes in the exchange rate regime over time have likely impacted on the inflation dynamics. However, it is difficult to capture or measure the influence of these forces empirically and it is therefore desirable to model them as an unobserved variable. The results suggest that once a serially correlated omitted variable is allowed for, the model fits the data much better, and also explains some surprising features of simple Phillips-curve estimates.

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Table 1. Correlation of Alternative Measures of Inflation

Annual Data, 1979-2003

	CPI	Deflator	RPI	PPI
CPI	1			
Deflator	0.928	1		
RPI	0.995	0.923	1	
PPI	0.919	0.924	0.924	1.000

Notes: Inflation is measured using the consumer price index (CPI; from 1985), the GDP deflation (Deflator; from 1979), the retail price index (RPI; from 1979) and the producer price index (PPI; from 1980). The exact sample periods vary depending on data availability. The correlations are computed using all available data.

Table 2. Estimates of the Unobservable-Components Model for the Output Gap

Annual Data, 1978-2003

$\phi_1 = 1.291$ (5.113)	$\sigma_\mu^2 \times 1000 = 0.008$	
$\phi_2 = -0.749$ (9.311)	$\sigma_\varepsilon^2 = 0$	$\sigma_z^2 \times 1000 = 0.346$

Table 3. Correlations of Alternative Measures of the Output Gap

Annual Data, 1978-2003

	HPGAP	UCGAP	TGAP
HPGAP	1		
UCGAP	0.979	1	
TGAP	0.959	0.891	1

Notes: The output gaps are computed using the Hodrick-Prescott filter (HP), the unobservable components method of Gerlach and Yiu (2004) (UC) and a cubic time trend (TGAP).

Table 4. Estimates of Alternative Phillips-Curve Models

Annual Data, 1982-2003

Regression	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Price index Output gap	GDP Deflator HPGAP			GDP Deflator UCGAP			RPI HPGAP			RPI UCGAP		
α	0.015 (1.308)	0.017 (1.754)	0.14 (1.258)	0.016 (1.302)	0.019 (1.986)	0.016 (1.403)	0.019 (1.460)	0.017 (1.418)	0.015 (1.091)	0.021 (1.565)	0.021 (1.757)	0.019 (1.380)
β_1	0.707*** (4.405)	1.044*** (5.802)	1.137*** (3.963)	0.701*** (4.180)	1.014*** (5.706)	1.086*** (3.855)	0.621*** (3.898)	1.018*** (5.327)	1.004*** (3.38)	0.593*** (3.583)	0.989*** (5.279)	0.960*** (3.222)
β_2		-0.379* (2.087)	-0.544 (1.559))		-0.380** (2.115)	-0.516 (1.522)		-0.364* (1.990)	-0.390 (1.080)		-0.384** (2.159)	-0.380 (1.070)
β_3			0.124 (0.594)			0.120 (0.549)			0.078 (0.367)			0.058 (0.275)
δ_0	0.177 (0.678)	0.741** (2.613)	0.788 (1.447)	0.140 (0.574)	0.735** (2.789)	0.722 (1.364)	0.605* (1.895)	1.135*** (2.936)	0.955 (1.312)	0.532* (1.796)	1.075*** (3.071)	0.878 (1.248)
δ_1		-0.805*** (2.884)	-0.933 (1.143)		-0.787*** (3.006)	-0.827 (1.030)		-0.967** (2.415)	-0.672 (0.576)		-0.914** (2.464)	-0.590 (0.512)
δ_2			0.116 (0.118)			0.041 (0.068)			-0.211 (0.252)			-0.238 (0.288)
Adj. R-sq. DW	0.510 1.245	0.705 1.758	0.674 1.872	0.507 1.255	0.715 1.765	0.684 1.863	0.509 1.183	0.659 1.943	0.619 1.904	0.500 1.176	0.668 1.965	0.628 1.905

Notes : Absolute value of t-statistics in parentheses, */**/*** denotes significance at 10/5/1% level.

Table 5. Estimates of A Phillips-Curve Model with Omitted Variables

Regression	1	2
α	0.126 (0.441)	0.050** (2.183)
θ_1	1.314*** (5.159)	1.219*** (5.673)
θ_2	-0.435 (1.721)	-0.495** (2.170)
β	-0.184 (0.687)	
δ	0.985* (2.094)	1.136** (2.641)
Adj. R-sq. DW	0.697 1.831	0.702 1.891
Log likelihood	48.817	48.390

Notes: Absolute value of t-statistics in parentheses, */**/*** denotes significance at 10/5/1% level.

Figure 1
Alternative Measures of Inflation

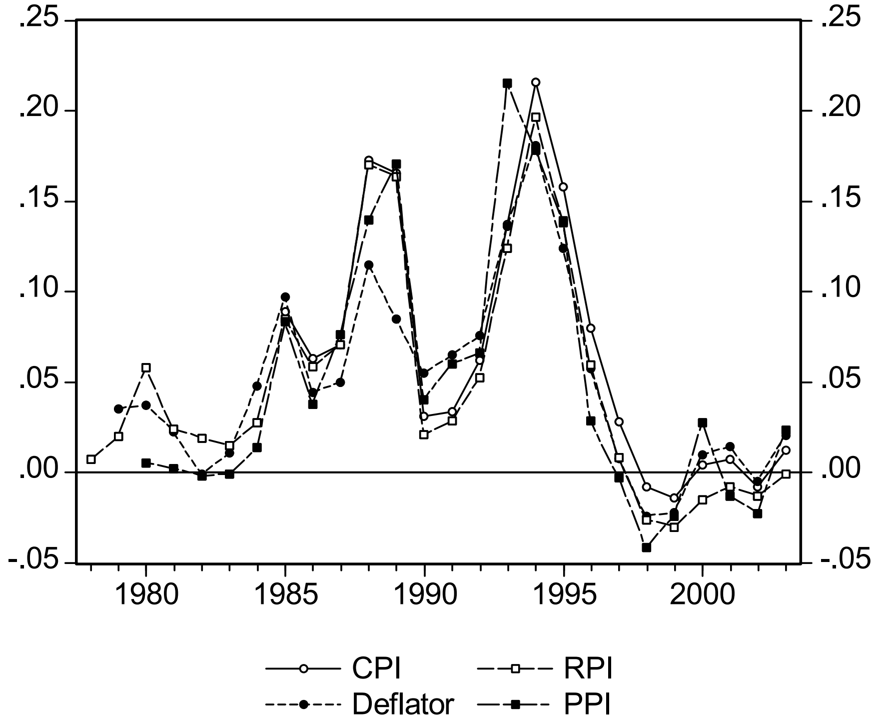

Figure 2
Estimates of the the Growth Rate of Potential Output
(together with 95 percent confidence band)

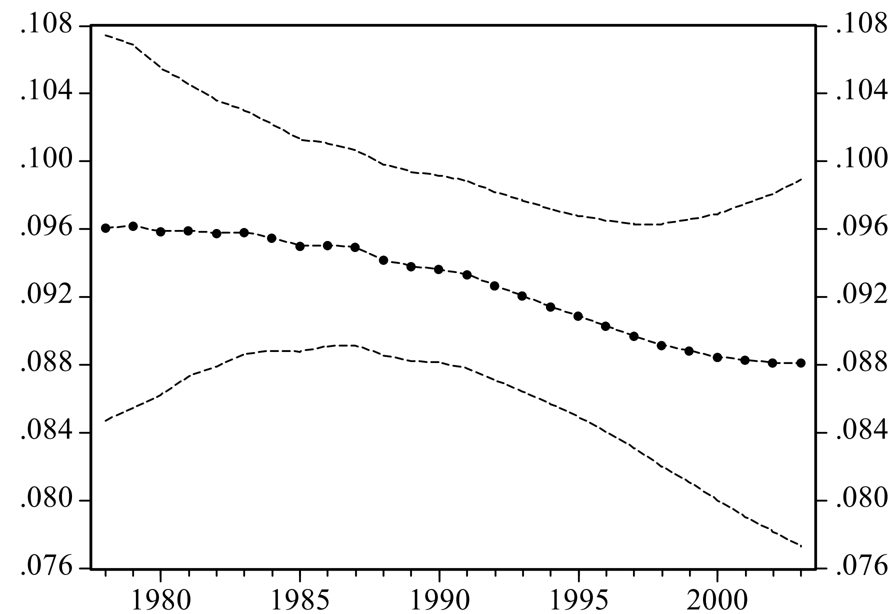

Figure 3
Estimates of UC Gap
(together with 95 percent confidence band)

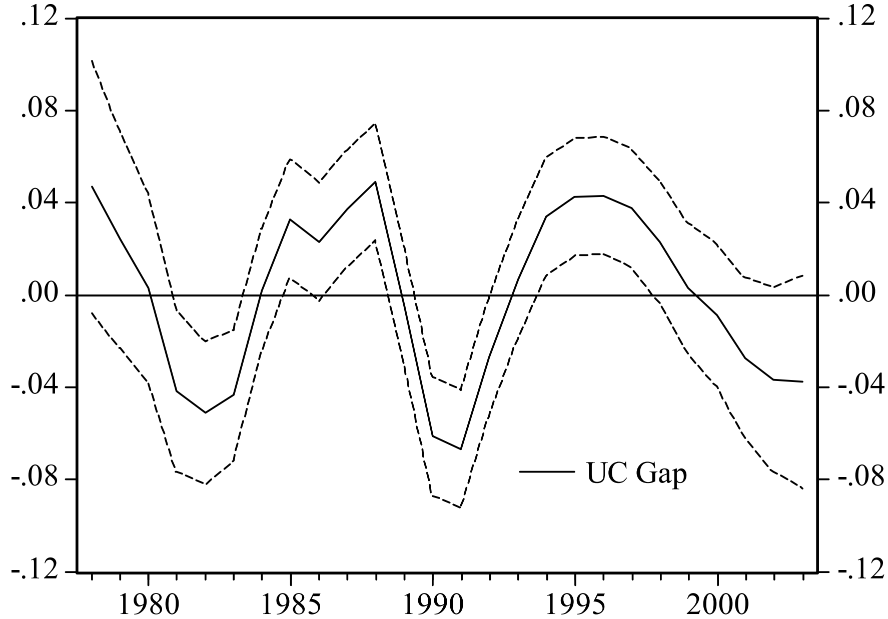

Figure 4
HP Gap and T Gap
(together with 95 percent confidence band from UC Gap)