FEATURE ARTICLE

The Causes of Inflation and Deflation in Mainland China

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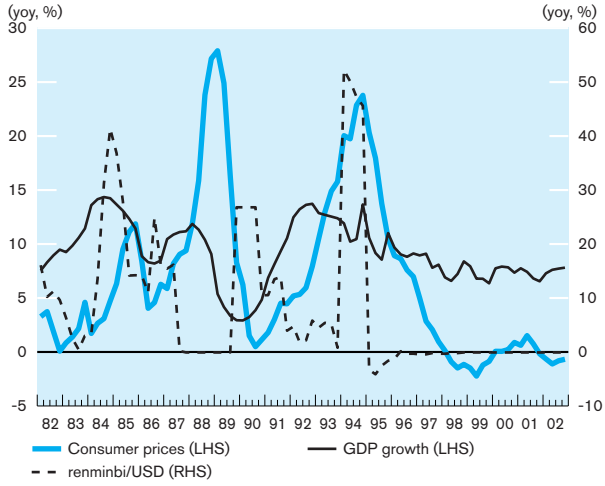
Price developments in Mainland China have important implications for Hong Kong because of the increasing economic integration between the two economies. In this study of inflation dynamics on the Mainland, world prices, the value of the renminbi and the level of productivity are found to govern long-run price movements in China. Specifically, high inflation between 1990 and 1997 was due mainly to rising world prices and the devaluation of the renminbi, while low inflation and deflation in recent years reflected productivity growth and the appreciation of the effective exchange rate following the Asian financial crisis.

I. INTRODUCTION

Mainland China has experienced several distinct phases of price adjustment since economic reforms were initiated more than two decades ago (Chart 1). Price liberalisation and surges in investment financed by monetary expansion led to considerable price increases in the 1980s. Devaluation of the renminbi also contributed to inflation.[1] As a result, the year-on-year CPI inflation rate reached a high of close to 30% in 1989, before moderating to single digits in the early 1990s after a tightening of monetary policy.[2] Inflation began to accelerate in 1993 along with higher economic activity spurred by resumed economic reforms following a period of sub-par growth in the early 1990s. However, the economy has experienced remarkable disinflation since the mid-1990s and has undergone some deflation since 1998.[3]

CHART 1

Inflation, Growth, and Nominal Exchange Rate, 1982-2002



Deflation is of particular concern to economies that are closely integrated with Mainland China. Notably, price movements in the Mainland have important implications for Hong Kong which has experienced deflation during the past five years. Ha and Fan (2002) find that about a quarter of the deflation in Hong Kong may be attributable to the process of price convergence with the Mainland.

Nevertheless, few studies have examined recent inflation dynamics in Mainland China, despite its importance to the world and regional economies. The IMF (2003) argues that deflation on the Mainland in recent years was caused by both transitory and

[1] The renminbi was devalued from 3.2 yuan/USD to 3.7 yuan/USD in July 1986 and to 4.7 yuan/USD in December 1989.

[2] Growth in bank loans declined from close to 40% per annum in 1986 to below 20% in 1992.

[3] Consumer prices began to fall in 1998 as the economy slowed in the wake of the Asian financial crisis, and this lasted until 2000. Deflation resurfaced during late 2001–end-2002, peaking in April 2002 at a year-on-year rate of 1.3%.

long-term supply shocks. The former included lower commodity prices and WTO-related tariff cuts, while the latter was associated with productivity gains arising from reforms of state-owned-enterprises (SOEs), adoption of new technologies and greater competition from more open markets. The IMF paper concludes that continued expansion in capacity and excess labour could continue to depress prices and prevent the Balassa-Samuelson effects from taking hold. However, these conclusions are yet to be backed by empirical evidence. Earlier work on inflation on the Mainland tends to focus on monetary factors and business cycles. Chen (1997) estimates money demand functions using annual data from 1951-1991. Based on the stable relationships established between money and income, he suggests that the targeted M2 annual growth rate should not exceed 28-29% in order to keep inflation below 10%. Using data from a similar period, Hasan (1999) finds evidence that monetary forces have predictable influence on price movements, and also calls for controls on monetary growth as a means of holding down inflation. In characterising the macroeconomic cycles the Mainland experienced between the late 1970s and 1997, Oppers (1997) finds that the inflationary episodes were associated with sharp increases in aggregate demand.

This article provides an empirical analysis of inflation dynamics on the Mainland in recent years, with a view to identifying and assessing the importance of factors underlying price movements. A commonly used approach to study inflation dynamics is the conventional Phillips curve, which relates inflation to the output gap — an increase (decrease) in the output gap exerts an upward (downward) pressure on prices. However, one of the disadvantages of this approach is the difficulty in estimating the level of potential output, particularly if the economy under study has undergone significant structural changes. In this regard, this article uses an alternative approach — the new Phillips curve, which relates the general price level to prices of production factors. Measures of real marginal cost are used in the inflation equation in lieu of an *ad hoc* measure of the unobservable output gap. This approach is appealing in that it is based on explicit micro-foundations relating inflation to price setting behaviour at the firm level.

This article is organised as follows. Section II outlines the new Phillips curve approach, which provides the theoretical foundation for the empirical work that follows. Section III demonstrates that the conventional Phillips curve fails to properly characterise inflation dynamics on the Mainland. Section IV uses the new Phillips curve to model inflation dynamics on the Mainland. Section V estimates a wage equation, with a view to identifying factors determining the unit labour cost. This is followed by derivation in Section VI of a reduced-form solution for inflation, which is then used to decompose the contribution of various determinants to consumer price movements. Section VII offers some concluding remarks.

II. THE NEW PHILLIPS CURVE

A widely used approach to model inflation is the conventional Phillips curve. In expectations-augmented form, it can be written as:

$$(1) \qquad \Delta p_t = c_1 + c_2 gap_t + c_3 E_{t-1} \Delta p_t ,$$

where p is the price level (in log), gap represents the output gap — the deviation of actual output from potential, Δ denotes change, and E_t stands for expectations conditional on information available at period t.

Since the output gap is unobservable, estimation of the conventional Phillips curve requires potential output to be estimated. A number of methods — for instance, the production function approach, the Hodrick-Prescott (HP) filter, or the Kalman filter — can be used to estimate potential output.[4] However, it is notoriously difficult to measure potential output for economies that have been experiencing significant structural changes, such as the Mainland.

[4] Scacciavillani and Swagel (1999) provide a survey of methodologies for estimating potential output.

An alternative approach, known as the "New Phillips Curve", avoids directly estimating the output gap. Instead, it seeks to establish explicit microfoundations for price formation through modelling price setting at the firm level. Building on the model by Calvo (1983), the new Phillips curve casts the pricing decision within the optimisation problem of a representative firm in a competitive environment.

The price setting behaviour arises from optimisation by competitive firms subject to the cost of frequent price adjustment. A fraction of firms in the economy change prices in a given period and then keeps them constant for several periods. Competition leads to a mark-up of prices over marginal costs and the infrequent adjustment of prices implies that both current and expected future marginal costs are relevant in price setting. Aggregating individual firms' behaviour leads to a relationship that links inflation in the short run to a measure of overall real marginal cost, similar in form to the traditional Phillips curve:

$$(2) \qquad \Delta p_t = c_1 + c_2 rmc_t + c_3 E_t \Delta p_{t+1}.$$

Equation (2) is referred to as the benchmark model of the new Phillips curve. It differs from the conventional Philips curve in two major aspects: expectations are forward looking and the term measuring excess demand has been replaced by a term incorporating real marginal cost (*rmc*). The value of c_2 depends on the underlying structural parameters of the optimisation model by Calvo, particularly the parameter that governs the degree of price rigidity. Specifically, let θ denote the probability that a firm keeps its prices fixed during any given period, and it can then be shown that:

$$(3) \qquad c_2 = \frac{(1-\theta)(1-\beta\theta)}{\theta}, \qquad c_3 = \beta$$

where β represents the discount factor.

The benchmark model can be extended to incorporate a lagged term of the dependent variable:

$$(4) \qquad \Delta p_t = c_1 + c_2 rmc_t + c_3 E_t \Delta p_{t+1} + c_4 \Delta p_{t-1},$$

which is often referred to as the hybrid model of the new Phillips curve. Fuhrer and Moore (1995) and Fuhrer (1997) show that the empirical performance of equation (2) can be improved by adding lags of inflation. On theoretical grounds, this can be justified by assuming that a fraction of firms are forward looking in their price setting behaviour, while the remainder use a rule of thumb based on past inflation.

Similarly, the coefficients in equation (4) can be related to the underlying parameters of the structural model by Calvo. Assuming that the fraction of backward looking firms is ω and the probability of adjusting prices in any given period is $1-\theta$, then the coefficients in (4) can be expressed as:

$$(5) \qquad c_2 = \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\theta+\omega[1-\theta(1-\beta)]}, \quad c_3 = \frac{\beta\theta}{\theta+\omega[1-\theta(1-\beta)]}, \quad c_4 = \frac{\omega}{\theta+\omega[1-\theta(1-\beta)]}.$$

Since real marginal cost cannot be observed directly, there is a need to construct a measure based on observable variables. Conditional on this measure, estimates of the structural parameters such as θ and ω can be recovered.

The new Phillips curve has been estimated for a number of economies. Galí and Gertler (2000, 2001) estimate one form of equation (2) by considering a model where labour is the only variable input. Assuming further that the marginal cost of labour is proportional to the average cost, their measure of real marginal cost is equal to the labour share. They find that the new Phillips curve fits the US and euro zone data well. Genberg *et al.* (2003) argues that import prices, wages and property prices are important sources of changes in marginal costs in Hong Kong. They find that although both the traditional and new Phillips curves can be used to characterise Hong Kong's inflation dynamics, the data appear to fit the latter better.

This study estimates both the conventional and new Phillips curves for the Mainland. Data used for the

estimation span from 1989Q1 to 2002Q4. The Consumer Price Index (CPI) is used to measure inflation. The real marginal cost is constructed by using trade-weighted world prices in renminbi terms and unit labour cost. Let p^*, $neer$, w, y, and l denote respectively the logarithms of the level of (trade-weighted) foreign price, the (trade-weighted) nominal effective exchange rate, wage rate, output and employment. Marginal cost may be proxied by a linear combination of import prices, $p^* - neer$, and the unit labour cost, $w+l-y$. The real marginal cost can be written as:

(6) $$rmc = \beta_1(p^*-neer) + \beta_2(w+l-y)-p \ .$$

Long-run homogeneity holds if $\beta_1 + \beta_2 = 1$, implying an underlying production function of constant returns to scale.

III. ESTIMATING THE CONVENTIONAL PHILLIPS CURVE

Before estimating the new Phillips curve, this section attempts to model inflation in Mainland China using the conventional Phillips curve discussed in Section II. Two methods are used to calculate potential output. One applies the HP filter, and the other regresses actual output on a linear trend. The output gaps generated by these two methods are similar. Both the CPI inflation and the output gap are found to be stationary by unit root tests (Table 1).

The estimation results presented in Table 2 suggest that the conventional Phillips curve is unable to properly characterise inflation dynamics on the Mainland. Column (1) reports the estimates for

TABLE 1
Unit Root Test Statistics

	Level		First Difference	
	ADF	PP	ADF	PP
p	1.35	-1.63	-3.33**	-5.63**
$p^* - neer$	-2.12	-1.82	-5.85**	-6.02**
$w+l-y$	-2.60	4.21	-7.96**	-8.01**
Gap	-4.71**	-1.95*		
Gap1	-2.56**	-1.11		

Notes:
a) *, ** denote significance at the 5% and 1% levels.
b) *Gap* and *Gap1* refer to the output gaps computed using the Hodrick-Prescott filter and a linear trend respectively.

TABLE 2
Estimation of the Inflation Equation with the Output Gap

Dependent variable: π_t	(1)	(2)
π_{t-1}	0.92** (0.058)	0.54** (0.063)
π_{t+1}	–	0.46
Gap_t	0.17 (0.243)	0.08 (0.072)
Adjusted R-squared	0.93	0.99
Durbin-Watson statistics	0.72	2.38

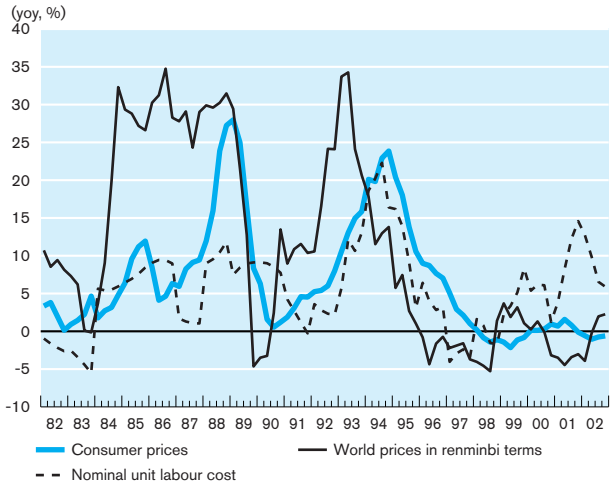
Notes:
a) Numbers in parentheses are standard errors.
b) GMM is used in estimating the model that includes the lead inflation rate.
c) ** indicates significance at the 1% level.

equation (1) — the original form of the conventional Phillips curve in which only a lag of inflationary expectations is included as an explanatory variable. It performs poorly as the output gap is not significant. Some previous studies also adopt a modified form of the conventional Phillips curve, which incorporates a lead term of inflationary expectations as an additional explanatory variable. This specification is estimated, using Generalised Methods of Moments (GMM) to account for the endogeneity of future inflation, and reported in Column 2. Since statistical tests cannot reject the hypothesis that the coefficients on the lead and lag terms of expected inflation sum up to one (p-$value$ = 0.97), the restriction is imposed in the estimation. The inclusion of the lead term is found to improve explanatory power. However, the output gap is still insignificant.

The failure of the conventional Phillips curve reflects the difficulty in obtaining accurate estimates of potential output for the Mainland, which has been experiencing wide-ranging structural changes in the economy. As a result, indicators of the output gap are subject to measurement errors and hence do not adequately reflect pressure on prices. In particular, statistical methods based on actual output are likely to underestimate potential output because they fail to take account of increases in excess labour supply and production capacity on the Mainland. This observation may be helpful for understanding the puzzle of disinflation/deflation that was accompanied by rapid economic growth in recent years.

CHART 2

CPI Inflation, World Prices, and Unit Labour Cost



IV. ESTIMATING THE NEW PHILLIPS CURVE

Since the conventional Phillips curve fails to work adequately, this section uses the new Phillips curve to model inflation dynamics on the Mainland. A preliminary preview of the data indicates that world prices and the unit labour cost play an important role in the inflation process (Chart 2). This suggests a transmission mechanism where imported goods are used as inputs together with labour in the production of domestic goods.

As a first step, the Augmented Dickey-Fuller and Phillips-Perron tests are applied to investigate the time series property of consumer prices (p), world prices in renminbi terms (p^* - $neer$), nominal unit labour cost (w+l-y). The test statistics shown in Table 1 indicate that all the variables are integrated of order one. The long-run price relationship and short-run inflation dynamics are estimated below.

Long-run Price Determination

The Johansen (1995) approach is used to establish the long-run relationship between the CPI and its determinants. The methodology has the advantage of identifying possible long-run relationships among variables within a multivariate co-integration framework. Column 1 in Table 3 shows that the CPI is found to be co-integrated with the world price and the unit labour cost. As the hypothesis of homogeneity cannot be rejected (p-value = 0.43), Column 2 shows the results with the restriction $\beta_1+\beta_2=1$.

TABLE 3

Test of CPI Co-integration with Marginal Cost Variables

Co-integrating vector:	(1)	(2)
p^* - $neer$	0.67**	0.68**
	(0.038)	(0.045)
w+l-y	0.41**	0.32**
	(0.046)	(0.045)

Notes:
a) Numbers in parentheses ( ) are standard errors.
b) ** indicates significance at the 1% level.

The results suggest that world prices (including exchange rate movements) and the nominal unit labour cost are long run determinants of consumer prices. They contribute about 70% and 30%, respectively, to inflation. The perception is that not only are changes in prices of imported inputs passed on to consumer prices, but also growing integration with the global economy bring prices of domestic products, regardless of their import content, in line with the international level. Compared with Genberg *et al*. (2003), which find that wages account for 40% of production costs in Hong Kong, the smaller contribution by the unit labour cost appears consistent with the fact of lower labour costs on the Mainland.

Short-run Inflation Dynamics

The theory underlying the new Phillips curve implies an equation that explains inflation by the deviation of actual real marginal cost from its equilibrium level together with past inflation and current expectations of future inflation, as shown by equation (4). To estimate the parameters in the equation, it is assumed that real marginal cost can be measured as a linear combination of the world price level and unit labour cost, pursuant to the results of the co-integration analysis. The restriction $c_4 = 1\text{-}c_3$ is imposed to ensure dynamic homogeneity. To account for the endogeneity of future inflation, GMM is used to estimate the parameters. The point estimates of c_2 and c_3 can be used to calculate the implied values of θ and ω, using equation (5).[5]

The implied values of the parameters θ and ω suggest prices remain fixed for about three quarters on average and that about one-third of the firms on the Mainland are forward looking (Table 4). This can be compared to the estimates in Genberg *et al*. (2003), which imply that prices remain fixed for between 2.5 and three quarters and that over 60% of the firms in Hong Kong are forward looking. Galí and Gertler (1999) find that prices stay fixed for about five quarters in the United States. These results point to a higher degree of price flexibility in Hong Kong than on the Mainland.

TABLE 4
GMM Estimates of Equation (4)

Coefficients:		
c_2	0.024*	(0.009)
c_3	0.506**	(0.028)
Implied value of parameters:		
θ	0.69	
ω	0.67	

Notes:
a) Numbers in parentheses ( ) are standard errors.
b) * and ** indicate significance at the 5% and 1% levels respectively.

Overall, the new Phillips curve characterises inflation dynamics on the Mainland better than the approach using the output gap. This is probably because the former avoids estimating potential output for an economy undergoing structural changes. Also, it directly considers the impact of world prices and unit labour cost, factors that the latter is unable to adequately account for.

V. WAGE DETERMINATION

Nevertheless, a drawback of the new Phillips curve approach is that the model sheds little light on the behaviour of the determinants of inflation. The above study finds that consumer prices are co-integrated with import prices and the unit labour cost. While the level of international prices and the nominal effective exchange rate are exogenously determined in a pegged exchange rate regime, a question arises as to what determines the unit labour cost. To address this issue, a wage equation is estimated below.

In theory, real wages depend on labour productivity in the long term, although they are also influenced by labour market conditions in the short run. An increase in productivity and a decline in excess

[5] The value of the discount factor, β, is assumed to be 0.99. The results are not sensitive to plausible values of β.

labour supply exert upward pressures on wages. In this connection, a wage equation may be specified as follows:

$$(7) \qquad w\text{-}p = \alpha_0 + \alpha_1(y\text{-}l) - \alpha_2(u\text{-}u^*) \ ,$$

where u and u^* denote the actual and natural rate of unemployment, respectively. Equation (7) implies that given the level of productivity, real wages decline when the unemployment rate exceeds its natural rate. When the unemployment rate converges to its natural rate in the long run, however, real wages depend on the level of productivity only.

The following analysis is focused on long-term wage determination because it can be combined with the above co-integrating relationship for prices to derive a reduced-form solution to the equilibrium price level. Also, data on the unemployment rate are subject to considerable measurement errors because they do not reflect hidden unemployment in the state sector or employment in the informal sector. Finally, it is probably more difficult to measure the natural rate of unemployment than potential output on the Mainland, which has undergone significant structural changes in its labour market along with reforms of enterprise ownership and the social security system. Because of these considerations, the unemployment gap, $u - u^*$, is dropped when estimating equation (7).

The estimation results are reported in Table 5. It is important to note that the estimated value of α_1 is smaller than unity, suggesting that wages fell behind productivity growth over the sample period.[6] The results reflect excess labour supply, which prevents the Balassa-Samuelson effects from taking hold, as noted by the IMF (2003).

TABLE 5
Estimation of the Long-run Wage Equation

Explanatory variables:	
Constant term	2.16** (0.178)
Labour productivity	0.48** (0.079)
Adjusted R-squared	0.42
Durbin-Watson statistics	1.71

Notes:
a) Numbers in parentheses ( ) are Newly-West HAC standard errors.
b) ** indicates significance at the 1% level.

[6] The null hypothesis of α_1 being equal to unity is rejected with a p-value close to zero.

VI. REDUCED-FORM SOLUTIONS

The co-integrating relationship found in Section IV indicates that consumer prices in the long run are a linear combination of world prices and the nominal unit labour cost:

$$(8) \qquad p = \beta_1(p^* - neer) + (1-\beta_1)(w+l-y)$$

where p^* and $neer$ are the logarithms of the international price level and the nominal effective exchange rate of the renminbi. The value of β_1 is estimated to be 0.68, as shown before. Substituting the long-term version of equation (7), which excludes the unemployment gap, into equation (8) yields a reduced-form equation for the consumer prices, with the constant term omitted without loss of generality:

$$(9) \qquad p = (p^* - neer) + \frac{(\alpha_1 - 1)(1-\beta_1)}{\beta_1}(y-l)$$

Equation (9) relates consumer prices to the international price level, the effective exchange rate and productivity. A number of observations are worth noting. First, changes in international prices and the effective exchange rate have full impact on domestic inflation in the long run. Secondly, productivity growth exerts a downward pressure on domestic prices because the estimated value of α_1 is smaller than unity, reflecting a smaller increase in the real wage than productivity growth.

The reduced-form solution can be used to decompose the contributions of the three explanatory variables to the price movements during the sample period, which may be divided into an "inflation period" (1990-1997) and a "deflation period" (1998-2002). The decomposition shows that the increase in the international price level, the

depreciation of the NEER and productivity growth contributed 67%, 53%, and -20% respectively to inflation during 1990-1997 (Chart 3). By contrast, world inflation slowed sharply, the NEER appreciated, and productivity growth continued during 1998-2002 (Chart 4), contributing -26%, 64% and 62% respectively to deflation.

The results suggest that inflation during 1990-1997 was due to the confluence of rising world prices and the devaluation of the renminbi, with the latter reflecting monetary loosening. The inflationary pressure was only partly offset by productivity growth, which outpaced wage increases. In the following five years, inflation among Mainland China's trading partners moderated, but continued to cast some upward pressure on domestic prices. However, this was more than offset by continued productivity growth and an appreciation of the renminbi, together with the US dollar, in the wake of the Asian financial crisis. These findings suggest that a hypothetical revaluation of the renminbi is unlikely to raise the real effective exchange rate if wage increases continue to lag behind productivity growth as a result of excess labour supply.

CHART 3

Contributions to Inflation

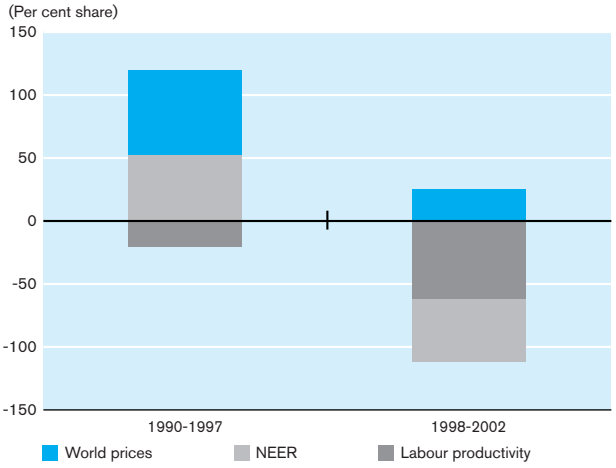
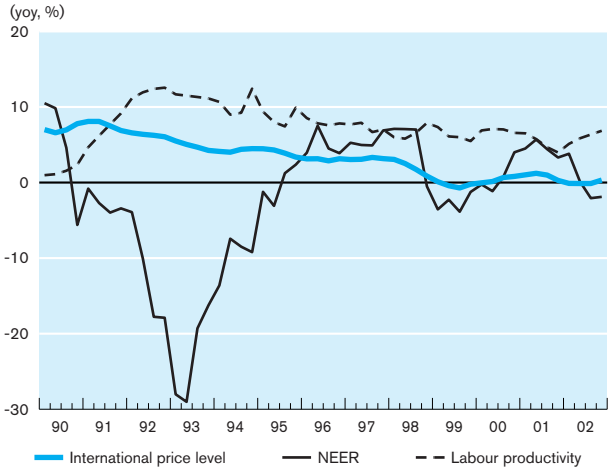


CHART 4

International Price Level, NEER, and Labour Productivity



VII. CONCLUSION

This article demonstrates that the conventional Phillips curve fails to account adequately for the inflation dynamics mainly due to the difficulty in estimating the potential output of Mainland China, which has undergone significant structural changes to its economy. By contrast, the new Phillips curve — which relates prices to marginal cost — characterises the Mainland's inflation reasonably well. World prices, the exchange rate of the renminbi and the unit labour cost are found to be among the long-run determinants of inflation. Estimating a wage equation suggests that excess labour supply prevents Balassa-Samuelson effects from playing a significant role. Deflation, or low inflation, in recent years reflect rapid productivity growth, an appreciation of the effective exchange rate in the wake of the Asian financial crisis and moderating inflation in the Mainland's trading partners.

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