

THE CAUSES OF INFLATION AND DEFLATION IN CHINA

(Preliminary draft)

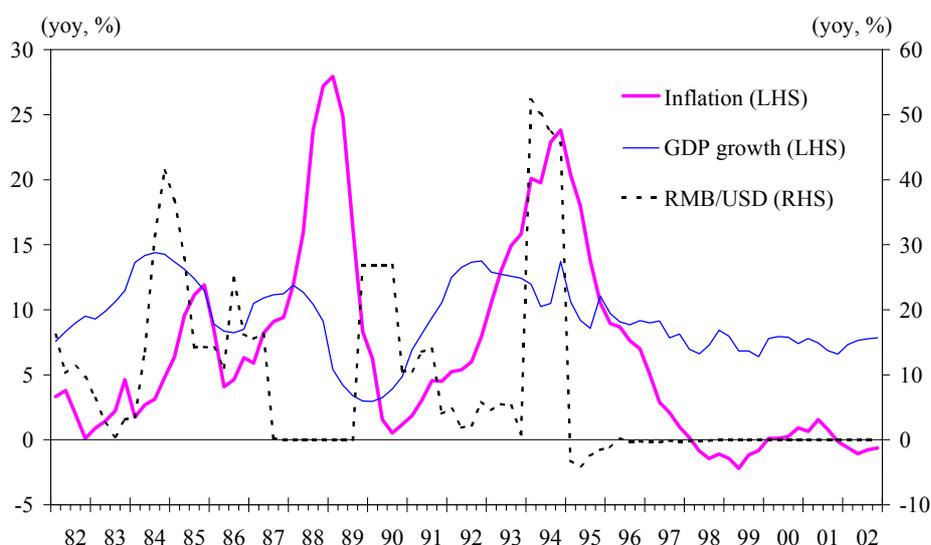
Key points:

- *This paper studies inflation dynamics in the Mainland of China over the past one and a half decades by estimating a new Phillips Curve.*
- *World prices, the value of the RMB, and the level of productivity are found to be the key variables governing long-run price movements in the Mainland. The high inflation during 1990-1997 was attributable mainly to the increase in the international price level and the devaluations of the RMB, while the low inflation and deflation in the recent years reflected productivity growth and the appreciation of the effective exchange rate following the Asian financial crisis. The results suggest that a hypothetical RMB revaluation at this stage would add to the deflationary pressure arising from excess supply of labour.*
- *In the short run, domestic prices adjust in response to inflationary expectations and the marginal cost of production. The speed of adjustment is found to be slower and the share of forward-looking firms smaller in the Mainland than in Hong Kong, reflecting higher degrees of price flexibility and monetary policy transparency in the latter.*
- *The conventional Phillips curve is found not to account adequately for inflation dynamics in the Mainland, due probably to the difficulty in estimating potential output of the economy, which has undergone significant structural changes.*

I. INTRODUCTION

The Mainland of China has gone through several distinct phases of price adjustment since economic reforms were initiated more than two decades ago (Chart 1). Price liberalisation and upsurges in investment financed by monetary expansion led to considerable price increases in the 1980s. Meanwhile, the devaluation of the RMB also contributed to the 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 digit in the early 1990s following the tightening of monetary policy.² Inflation began to accelerate in 1993 along with elevated 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 mid-1990s, and undergone some deflation episodes since 1998.³

Chart 1. Inflation, Growth, and Nominal Effective Exchange Rate, 1982-2002



With the growing importance of its economy, price developments in the Mainland will exert more influence on the world market. Inexpensive and abundant labour and large production capacity have helped the Mainland in the last 10 years gain market share in the United States and Japan. By 2002, its share in total U.S. imports reached 11%, overtaking Japan as the largest exporter to the United States; its share in total imports in Japan reached 18% during the same period. Although actual imports from the Mainland account for a small proportion of consumption in

¹ The RMB 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 1.3%.

most countries, the potential for increase appears to be large. As a result, price developments in the Mainland have attracted attention in its major trading partners and by competitors in the world export market. Deflation in the Mainland is of particular concern to economies that are closely integrated with it. Notably, price movements in the Mainland have important implications for Hong Kong—which has experienced deflation during the past 5 years—due in part to growing integration of the two economies. 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 the Mainland, despite its importance to the world and regional economies. IMF (2003) argues that deflation in the Mainland in recent years was caused by both transitory and long-term supply shocks. The former included lower commodity prices and WTO-related tariff cuts, while the latter was associated with productivity gains 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 in 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 control inflation below 10%. Using data from a similar period, Hasan (1999) finds evidence that monetary forces have predictable influence on price movements, and thus also calls for controlling 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 surges in the main components of aggregate demand such as consumption and investment.

This paper provides an empirical analysis of China's inflation dynamics of the 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 regards, this paper

uses an alternative approach—the new Phillips curve, which relates the general price level to prices of production factors. This approach is appealing in that it is based on explicit micro-foundations relating inflation to price setting behaviour at the firm level. Another key feature is that in empirical applications, measures of real marginal cost are used in the inflation equation in lieu of an *ad hoc* measure of the unobservable output gap.

The paper 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 in the Mainland. Section IV estimates the new Phillips curve. Section V estimates a wage equation. This is followed by derivation in Section VI of a reduced-form solution to inflation. 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:

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

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 change, such as the Mainland.

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

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

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 under the new Phillips curve 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 maintain them constant for a few periods. Competition leads to a mark-up of prices over marginal cost, and the infrequent adjustment of prices implies that both current and expected future marginal cost 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:

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

Equation (2) is referred to as the benchmark model of the new Phillips curve. It differs from the conventional one in two major aspects: expectations are forward looking in the new Phillips curve; 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, then it can be shown that:

$$(3) \quad \begin{aligned} c_2 &= \frac{(1-\theta)(1-\beta\theta)}{\theta}, \\ c_3 &= \beta \end{aligned}$$

where β represents the discount factor.

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

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

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 a theoretical ground, 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:

$$(5) \quad \begin{aligned} c_2 &= \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\theta + \omega[1-\theta(1-\beta)]} \\ c_3 &= \frac{\beta\theta}{\theta + \omega[1-\theta(1-\beta)]} \\ c_4 &= \frac{\omega}{\theta + \omega[1-\theta(1-\beta)]} \end{aligned} .$$

Since real marginal cost is not directly observable, a measure for it needs to be constructed 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. Gali 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) argue that import prices, wages, and property prices are important sources of changes in marginal cost 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 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 RMB 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:

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

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 the Mainland 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).

Table 1. Unit Root Test Statistics

	Level		First Difference	
	<u>ADF</u>	<u>PP</u>	<u>ADF</u>	<u>PP</u>
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		

Note:

- a) *, ** denote significance at the 5% and 1% levels.
- b) Gap is the output gap computed using the Hodrick-Prescott filter, while Gap1 is the one derived from a linear trend.

The estimation results presented in Table 2 suggest that the conventional Phillips curve is unable to properly characterise inflation dynamics in the Mainland. Column (1) reports the estimates for 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. As 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 its economy. As a result, the output gap is subject to measurement errors and hence does not adequately reflect pressure on prices. In particular, statistical methods based on actual output likely underestimate potential output because they fail to take account of excess labour supply and large production capacity in the Mainland. This observation may be helpful for understanding the puzzle of disinflation/deflation that was accompanied by rapid economic growth in the recent years.

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	

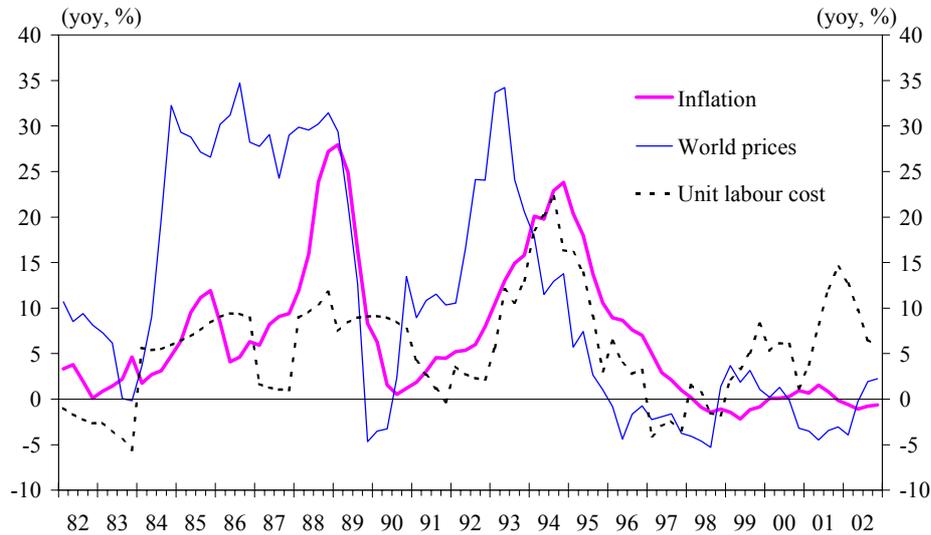
Notes:

- 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.

IV. ESTIMATING THE NEW PHILLIPS CURVE

As the conventional Phillips curve fails to work adequately, this section uses the new Phillips curve to model the Mainland's inflation dynamics. 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 RMB 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.

Chart 2. CPI Inflation, World Prices, and Unit Labour Cost

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 cointegration 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 Cointegration with Marginal Cost Variables

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

Notes:

a) Numbers in parentheses () are standard errors.

b) ** indicates significance at the 1% level.

The results suggest that world prices and the nominal unit labour cost are long run determinants of consumer prices. They contribute about 70% and 30%, respectively, to inflation. The intuition is that not only are changes in prices of imported inputs passed through 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. The value of the RMB—which in a way reflects the stance of monetary policy over the medium term under the fixed exchange rate regime—plays an important part in determining consumer prices. Compared with Genberg *et al.* (2003), which find that wages account for 40% of production cost in Hong Kong, the smaller contribution by the unit labour cost appears consistent with the fact of lower labour cost in 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 $c_4=1-c_3$ 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 3 quarters on average and that about one-third of the firms in 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 3 quarters and that over 60% of the firms in Hong Kong are forward looking. Gali and Gertler (1999) find that prices stay fixed for about 5 quarters in the United States. These results point to greater price flexibility in Hong Kong.

Overall, the new Phillips curve characterises inflation dynamics in the Mainland better than the approach using the output gap. This is probably because

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

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.

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.

V. W A G E D E T E R M I N A T I O N

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 cointegrated with import prices and the unit labour cost. While the level of international prices and, in a fixed exchange rate regime, the nominal effective exchange rate are exogenously determined, a question arises as to what determines the unit labour cost. To address this issue, a wage equation is estimated below.

Theory posits that real wages depend on labour productivity in the long run, although they are also influenced by labour market conditions in the short run. An increase in productivity and a decline in excess labour supply exert upward pressures on wages. In this connection, a wage equation may be specified as follows:

$$(7) \quad w - p = \alpha_0 + \alpha_1(y - l) - \alpha_2(u - u^*),$$

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-run wage determination, because it can be combined with the above-derived 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 in 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 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 New-West HAC standard errors.
- b) ** indicates significance at the 1% level.

VI. REDUCED-FORM SOLUTIONS

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

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

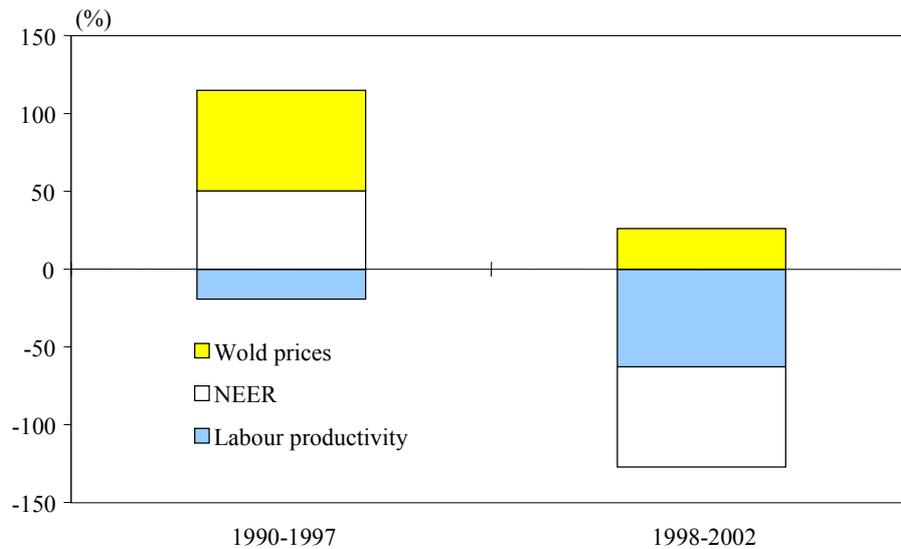
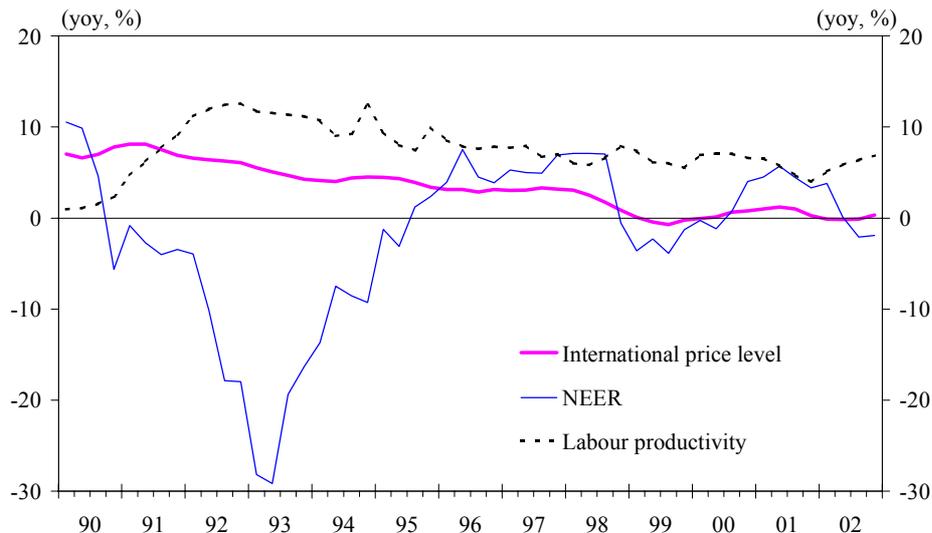
$$(8) \quad p = \beta_1(p^* - neer) + (1 - \beta_1)(w + l - y)$$

where p^* and $neer$ are the logarithm of the international price level and the nominal effective exchange rate of the Hong Kong dollar. 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:

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

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. Second, 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 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 the 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 the deflation.

Chart 3. Contributions to Inflation**Chart 4. International Price Level, NEER, and Labour Productivity**

The results suggest that inflation during 1990-1997 was due to the confluence of rising world prices and the RMB devaluation, 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 in the 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 RMB along with the US dollar in the wake of the Asian financial crisis. These findings suggest that a hypothetical revaluation of the RMB 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.

VII. CONCLUSIONS

This paper demonstrates that the conventional Phillips curve fails to account adequately for the inflation dynamics due probably to the difficulty in estimating potential output for the Mainland, which has undergone significant structural changes in its economy. By contrast, the new Phillips curve—which relates prices to marginal cost—characterises the Mainland’s inflation well. World prices, the value of the RMB, and the unit labour cost are found to be among the long-run determinants of inflation. Estimation of a wage equation suggests that excess labour supply prevents Balassa-Samuelson effects from playing a significant role. The deflation or low inflation of the recent years reflected rapid productivity growth, an appreciation of the effective exchange rate in the wake of the Asian financial crisis, and moderation in inflation in the trading partners. In the short run, domestic prices adjust in response to inflationary expectations and the marginal cost of production. Compared with the results in Genberg *et al.* (2003), however, the speed of price adjustment is slower and the share of forward-looking firms is smaller in the Mainland than in Hong Kong, reflecting higher degrees of price flexibility and monetary policy transparency in the latter.

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