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Abstract

Since 1998 Hong Kong has experienced over 16 quarters of deflation. Some asset prices such as factory and office space prices started to fall in early 1990s, a long time before the Asian crisis. The number of firms and businesses that have moved out of Hong Kong are not readily available, but it is quite plausible that firms and businesses relocated to the Mainland because they expected future marginal costs to fall in response to Hong Kong's handover to China in 1997. We estimate a Phillips curve specification, where changes in the price level are a function of expected inflation and the marginal cost. This model outperforms (in-and-out-of-sample) the traditional Phillips curve specification and other models of wage-price dynamics. Because the marginal cost is basically unit labour cost, the model suggests that wage and productivity dynamics play an important role in explaining price dynamics.

Keywords: Deflation, Phillips curve, Wages, Real Marginal Cost, Mark-up
JEL Classification: E31, C1, C5

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1. Introduction

Hong Kong adopted a currency board (CB) in 1983. The Hong Kong dollar was pegged to the US dollar at a fixed rate. It is understood that the reason for the adoption of the CB as a monetary arrangement was to maintain the integrity and the credibility of the financial system in Hong Kong, which is an important financial centre. It was clear in 1983 that China would assume sovereignty over Hong Kong in 1997. In the early 1990s, China was taking steps to regain sovereignty over Hong Kong in 1997. And in late 1997 the effect of the Asian financial crisis was felt in Hong Kong and the Hong Kong Monetary Authority decided to defend the CB.[1] Figure 1 plots the inflation rate in Hong Kong and shows that prices have been falling for the past four years.

Prices for private properties and retail space began to fall after the Asian crisis. However, examination of more data seems to suggest that some asset prices such as factory and office space prices started to fall in the early 1990s, not in 1997 or 1998, and they continue to fall. Figure 2 plots these prices. Figure 3 plots the relative prices. The currency board and the Asian crisis have something to do with the deflation, but they might not be the driving force. Instead, we think the deflation can be explained by China's decision to regain control of Hong Kong, announced in the early 1990s, which altered the businesses' expectations about future marginal costs and profits.

We postulate two hypotheses: First, changes in asset prices reflect optimal decisions taken by economic agents who, in the early 1990s as the transfer of sovereignty drew closer, expected the path of marginal costs in Hong Kong to fall to a lower level equivalent to that of Mainland China, which resulted in a continuous decline in the general price level. Unfortunately, data on the number of firms and businesses that have moved out of Hong Kong are unavailable. But it is quite plausible that the decline in office and factory space prices was a result of large relocations to the Mainland, where it is cheaper to operate. Second, the expected mark-ups over marginal costs could have fallen, which caused prices to fall. The objective of this paper is to test these two hypotheses and to further examine the nature of the dynamics of this process. Genberg and Pauwels (2003) studied this process first. This paper answers two questions. First, what model of price dynamics explains inflation/deflation in Hong Kong best? Second, what is the approximate time required for firms to change prices after the shock, i.e., price dynamics?

To answer these questions we examine different models. The maintained model of price-wage dynamics that economists typically use is the Phillips curve of Friedman (1968) and Phelps (1967). This Phillips curve explains the real wage bargaining dynamics – deviation of the nominal wage growth from expected inflation – as a function of the unemployment's deviations from its long-run steady state value or the so called natural rate of unemployment, where inflation expectations are assumed to be adaptive in the original literature.[2] Ha and Leung (2001) show that the traditional Phillips curve fits the Hong Kong data well. Unfortunately, this kind of the Phillips curve, which is typically estimated as a single-equation reduced-form model, does not place theoretically testable restrictions on the coefficients. The estimated

[1] The usual instruments that are available to a central bank to prevent a recession are not available under a currency board system, where the exchange rate is fixed.

[2] Later, Lucas (1973) introduced rational expectations into a formal model based on Friedman-Phelps; then it became a standard to use rational expectations in macroeconomic models.

reduced-form coefficients could not provide information about the frequency at which firms change prices. What is needed to answer our second question about the dynamics and the length of the adjustment period is a different specification of the Phillips curve such that we can place testable restrictions on the coefficients, and enable us to estimate the structural coefficients that govern the dynamic process.

There are two alternative specifications of the Phillips curve that allows us to test our hypothesis and answer the questions above. The first extends the Phillips curve of Friedman and Phelps and is derived under the assumption that the mark-up (price over marginal cost) is not constant. Dropping the assumption of a constant mark-up allows for a more general price-wage dynamic and places testable restrictions on the model. What is relevant for Hong Kong is whether unexpected permanent shocks to the mark-up, which affects the process of real wage bargaining, have an instantaneous effect on price dynamics or a dragging effect that actually affects price inflation in many periods in the future. We test the mark-up model of Whelan (1999).

The second alternative specification of the Phillips curve is the New Phillips curve of Gali and Gertler (1999). Genberg and Pauwels (2003) estimate the New Phillips curve for Hong Kong. In this Phillips curve the profit-maximizing firm, under the assumptions of monopolistic competition and sticky prices, chooses its optimal desired price by taking into account the entire future path of nominal marginal cost. The expected future path of marginal cost becomes relevant only when prices are sticky. If prices are not sticky, i.e., fully flexible, the adjustment is instantaneous, and firms set the price equal to the marginal cost.

In this paper, several *structural* parameters are estimated directly and theoretical cross-equation restrictions are tested. There is evidence that the New Phillips curve explains deflation in Hong Kong well. We estimate the probability of price changes in Hong Kong and the degree of forwardness in price setting. The probability of price change is significantly less than one and comparable to that estimated for the US economy. Like Genberg and Pauwels (2003), we find significant forwardness in inflation expectations.

The paper is organized as follows: in the next section we will derive different specifications of the Phillips curve. Section 3 includes the empirical results, where we compare the performances of the traditional Phillips curve with the new ones estimated in this paper in and out of samples. Section 4 is a summary.

2. The Phillips curve: Some popular specifications

The maintained model for short-run wage-price dynamics is the Phillips curve of Friedman (1968) and Phelps (1967), where inflation depends on expected inflation and the deviation of the unemployment rate from its natural rate. Note that in the original formulation of this Phillips curve, expectations were adoptive. There was no theory of expectations formation until Lucas introduced rational expectations in a series of influential papers. Nevertheless, the dynamic of inflation is sensitive to the dating of the information set. Next, I provide different popular specifications of the Phillips curve.

The Phillips curve represents the dynamic relationship between expected real wages and unemployment. The inflation equation is derived under the assumption that firms set prices as *constant* mark-ups over marginal costs. Workers bargain in terms of the real wage rather than the nominal wage. All variables that are measured in logs are represented by lowercase.

The wage equation is given by:

$$w_t - p_t^e = w_{t-1} - p_{t-1} + \Delta q_t + \alpha - \beta u_t + e_t \tag{1}$$

where w_t, p_t and q_t are the logs of nominal wages, the price level and labour productivity. The unemployment rate is u_t and p_t^e is the expected price level. The error term e_t has the usual classical properties.

Expected inflation follows adaptive expectations. The expected price level is:

$$p_t^e - p_{t-1} = p_{t-1} - p_{t-2} \tag{2}$$

Rearranging equation (1) and substituting for expected inflation Δp_t^e yields:

$$\Delta w_t = \Delta p_{t-1} + \Delta q_t + \alpha - \beta u_t + e_t \tag{3}$$

Firms set prices as a constant mark-up, μ, over unit labour costs. The log of the price mark-up μ is given by:

$$w_t - p_t = q_t - \mu \tag{4}$$

Equation (4) says that the average real wage is proportional to average labour productivity.

Taking the first difference, substituting into the wage equation, and letting $\Delta p_t = \pi_t$ yields the traditional Phillips curve.

$$\pi_t = \pi_{t-1} + \alpha - \beta u_t + e_t \tag{5}$$

But there are different formulations of the Phillips curve. The expectations-augmented Phillips curve with time-varying is given by:

$$\pi_t = \eta_1 E_{t-1} \pi_t - \eta_2 (u_t - u_t^*) + \varepsilon_t \tag{6}$$

Equation (6) is different from equation (5) in the sense that the dynamic is different due to the expectations' formation process, and the unemployment rate enters in deviations from its time-varying natural rate. The coefficient η_1 is hypothesised to be equal to unity. Both explanatory variables in the Phillips curve equation (6) are unobservable to the econometrician, while both explanatory variables were observable in equation (5).

The information set could be dated at time t, which also alters the dynamics and perhaps requires a different estimation technique. A similar equation to this kind of Phillips curve has also been used in the literature.

$$\pi_t = \eta_1' E_t \pi_{t+1} - \eta_2' (u_t - u^*) + \varepsilon_t' , \qquad (7)$$

where the natural rate is a constant and the information set is dated at time t. Some additional assumptions are required to estimate equations like (6) and (7). There is also a question of whether the coefficients are reduced-form or structural in such models. Another estimation problem, which is incidentally applicable to equation (5), is whether there is any single-equation bias (endogeneity), and how would that affect the estimation and the interpretation of the results.[3] These issues will be dealt with in section 3.

Whelan (1999) introduced the role of the price mark-up. The aggregate wage equation is given by:

$$w_t - p_t^e = \alpha + \rho(w_{t-1} - p_{t-1}) + \gamma_1 q_t + \gamma_2 q_{t-1} - \beta u_t + \zeta_t \qquad (8)$$

Substituting lagged real wage on the RHS of equation (8) with the time-varying mark-up, $w_{t-1} - p_{t-1} = q_{t-1} - \mu_{t-1}$ gives:

$$w_t - p_t^e = \alpha - \rho \mu_{t-1} + \gamma_1 q_t + (\rho + \gamma_2) q_{t-1} - \beta u_t + \zeta_t \qquad (9)$$

Substituting for expected price level $p_t^e = \Delta p_{t-1} + p_{t-1}$ gives:

$$w_t - p_{t-1} = \Delta p_{t-1} + \alpha - \rho \mu_{t-1} + \gamma_1 q_t + (\rho + \gamma_2) q_{t-1} - \beta u_t + \zeta_t \qquad (10)$$

Substituting out w_t from the mark-up equation to arrive at the price equation yields:

$$\Delta p_t = \Delta p_{t-1} + \alpha + \mu_t - \rho \mu_{t-1} + (\gamma_1 - 1) q_t + (\gamma_2 + \rho) q_{t-1} - \beta u_t + \zeta_t \qquad (11)$$

Similarly one could use $\Delta p_t = \Delta w_t - \Delta q_t + \Delta \mu_t$ to arrive at an expression for wages:

$$\Delta w_t = \Delta p_{t-1} + \alpha + (1 - \rho) \mu_t + \gamma_1 \Delta q_t - \beta u_t + \zeta_t \qquad (12)$$

The system (equations 11 and 12) places testable cross-equation restrictions on the coefficients. The coefficient ρ, which stirred a controversy about the specification of the traditional Phillips curve, plays a major role in this system. It measures the effect of the mark-up on both inflation and wages and it is also the degree of persistence in wages. The mark-up of prices over the marginal cost or unit labour cost is the inverse of the real marginal cost or the share of labour. The controversy about the mark-up model is found in Blanchflower and Oswald (1995) who estimated ρ from micro data to be 0.30 (or less) and argued that this value is inconsistent with the Phillips curve, where ρ is assumed to be one. When ρ is

3 The coefficient of expected inflation is one, which implies that in the long run, the Phillips curve is vertical. The interpretation is that in the long run, monetary policy is neutral, which implies that the monetary authority cannot exploit the short-run trade-off between unemployment and inflation to achieve long run gains in unemployment. In other words, it cannot increase inflation to achieve lower unemployment permanently. We have learnt this truth from lessons of monetary policy in the 1970s.

less than one the workers are assumed to care about the *level* of the real wage rather than the *rate of change*. There are implications to that, but they are beyond the scope of this paper. Card (1995), Blanchard and Katz (1999), Whelan (1999), and Rotemberg and Woodford (1999) argued about the specification of the model and the estimation method and presented evidence that ρ is closer to one than to 0.30 in the US data. The value of ρ is important for our purpose because it would provide a different interpretation of the nature of the dynamics of prices and wages. If ρ were to be unity, shocks to the mark-up would imply temporary adjustments in prices. The opposite is true if ρ were close to zero, which implies a dragging effect on prices. We will examine this important issue further in section 3.

Gali and Gertler (1999) provide the underlying motivation of the New Phillips curve. The New Phillips curve is derived under a set of assumptions that differ from those underlying Friedman's model. First, it is assumed that there is monopolistic competition rather than perfect competition, so firms are price-setters rather than price-takers. Second, prices are not fully flexible, and there is an adjustment cost. This means that firms may leave prices fixed or unchanged for many periods. The idea is cast in the spirit of staggered contract models such as Calvo (1983), where each firm, in any given period of time, has a fixed probability that it might adjust its price. Let θ measure the probability that the price remains unchanged. The *average* time over which the price remains fixed is approximately $1/1-\theta$.

Firms are assumed identical *ex ante*. Each firm faces a constant price elasticity demand curve. Under these assumptions, the aggregate price level is assumed to be a weighted-average of the past price level and a desired optimal price p_t^*:

$$p_t = \theta \, p_{t-1} + (1-\theta) \, p_t^* , \tag{13}$$

Prices are expressed as percent deviations from a zero-inflation in the steady state. Since firms are assumed to be identical, they choose the same price (except for the case of differentiated products). The firm also faces a marginal cost curve, mc_t (as a percent deviation from steady state), and given a discount factor $\widetilde{\rho}$ the firm can choose prices that maximize expected discounted profits subject to a time dependent pricing rule given:

$$p_t^* = (1-\widetilde{\rho}\theta)\sum_{i=0}^{\infty}(\widetilde{\rho}\theta)^i E_t(mc_{t+i}^n \ ) \tag{14}$$

Equation (14) says that firms choose prices that maximize expected discounted future profits, which take into account the expected future path of nominal marginal cost. If prices are fully flexible (θ =0) the firm adjusts its prices proportionately to changes in the current marginal cost. The expected future path of marginal cost becomes relevant, only when prices are sticky.

Again, letting inflation be $\pi_t = \Delta p_t$, Gali and Gertler derive the inflation equation:

$$\pi_t = \lambda mc_t + \widetilde{\rho} E_t \pi_{t+1} \tag{15}$$

The coefficient $\lambda = \frac{(1-\theta)(1-\widetilde{\rho}\theta)}{\theta}$ depends on the frequency of price adjustment and the discount factor, which are structural parameters. The coefficient λ is a decreasing function of and also depends on $\widetilde{\rho}$, while $\widetilde{\rho}$ itself is not a function of θ. Just like in the traditional Phillips curve, where expected inflation and the output or the unemployment gaps are unobservable, the marginal cost is also unobservable. The unemployment or the output gaps do not appear in the New Phillips curve. The same econometric problems that are associated with estimating the traditional Phillips curve and discussed above are still present. Note that the degree of forwardness in price setting and the degree of price stickiness are measured by separate parameters, i.e., $\widetilde{\rho}$ and θ, respectively.

Iterating equation (15) forward gives us:

$$\pi_t = \lambda \sum_{k=0}^{\infty} \widetilde{\rho}^k E_t(mc_{t+k}) \tag{16}$$

Equation (16) relates inflation to the sum of discounted future marginal costs, which is perfectly suitable to test our maintained hypothesis that firms in Hong Kong might have been operating under the assumption of a lower future path of marginal cost that reflects China's lower cost of labour. Next, we estimate different specifications Phillips curves for Hong Kong over the period 1986 to 2001 and test our maintained hypothesis.

3. Estimation and results

First, we estimate equations (5) and (7), which represent different specifications of the expectations-augmented Phillips curve.

Quarterly inflation is denoted $\pi_t = \Delta p_t$, where p_t is the log of the CPI. Log unemployment rate is u_t and $\widetilde{u}_t$ is the unemployment gap measured as the business cycle fluctuations of unemployment estimated using the Approximate Band-Pass filter, Baxter and King (1999). The assumption is that this filter isolates fluctuations within 6-32 quarters (I also tries the HP filter and found the results to be very similar).[4] Prior to manipulations, the data are seasonally adjusted. Details are reported in appendix 1.

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4 In my opinion, the only attractiveness of the filter is that it gives an economic definition of the business cycle, i.e., the fluctuations that lie between 6-32 quarters, which implies that the business cycle length is about eight years. All filters are subject to criticisms. The approximate BP filter extracts a specific range of periodicity, and otherwise leaves the properties of the extracted component unaffected. It introduces no phase shift (i.e., it does not alter the timing relationships between series at any frequency). It is optimal in the sense that it minimizes the discrepancies between the ideal filter and the approximate one using a loss function. The resulting business cycle fluctuations extracted from the filter are I(0) if it is applied to I(1) time series. The business cycle components resulting from the filter are unrelated to the length of the sample period (i.e., the constructed moving average is time-invariant). The filter has one problem; that is we lose observations from the beginning and from the end of the sample due to the two-sided moving average. To deal with that, one can either pad the series by assuming it follows an AR process and recover estimates of the lost data, or try a new method introduced by Corbae and Ouliaris (2002), which they claim resolves the issue.

Unit root

We use the ADF test for unit root. The ADF indicates that some time series are probably I (0), such as log unemployment, and others such as wages have explosive roots (the t test for ρ is positive) while the CPI is I (2), which means inflation is I (1). It is quite possible that the time series have some structural break. The ADF, which is not designed to account for breaks, confuses the break with a unit root.[5] We also used the KPSS test (Kwiatkowski-Phillips-Schmidt-Shin) to double check. This test also rejected the null (i.e., I (0)) in favour of a unit root for log CPI. There is a large literature that argues that some time series, like prices, might have two unit roots. Two unit roots means that shocks that happened in the distant past have stronger effects on the time series today than recent shocks. Having a unit root in the CPI inflation seems inconsistent with the success of the currency board in Hong Kong. To have a consensus about the best approximate orders of integration of the data we use several other tests for unit root, e.g., the Phillips-Perron and the Rothemberg-Elliott-Stock (1996) DF-GLS test in addition to the ADF. The results are reported in appendix 2.

The tests indicate that CPI inflation, probably, has a unit root. To resolve this issue, we will estimate the Phillips curve(s) using both the inflation rate and its first difference. We will not report the results of the latter, but they are available upon request.[6]

Only the DF-GLS test suggests that the log of unemployment has a unit root. The KPSS test was very difficult to interpret because the test statistics were borderline significant, therefore, we will examine both the log of the unemployment rate and the unemployment gap, which is stationary, when we estimate the Phillips curves. The Rothemberg-Elliott-Stock test suggests that wages are actually I (1), and do not have an explosive root.

On the issue of unit roots, McCallum (1993) demonstrates that it does not really matter whether the RHS variables of a linear regression are in level, first or second difference as long as the residuals are white noise. For those reasons, we will examine various specifications and carefully diagnose the residuals. We think this is a safe and a useful strategy. Before we report the regression results we provide scattered plots of the inflation and the unemployment rates in figure 4. The regressions' results of three specifications of the Phillips curve are reported in tables 1, 2 and 3.

The expectations-augmented Phillips curve, where expectations are adaptive, is estimated by OLS. The only problem with the specification of this Phillips curve is that unemployment is assumed and treated as a strictly exogenous variable. If unemployment were not an exogenous variable or at least a weakly exogenous variable, then OLS would produce a biased and inconsistent parameter estimate of β. The fit and the diagnostics are good. However, the coefficient of lagged inflation is different from one, which is inconsistent with the assumptions and the formulation of the Phillips curve, and raises some concerns.

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[5] Future research should try to examine the break in the CPI inflation. The Perron (1998) endogenous breakpoint test is probably a useful way to test if there is a break, and whether it is in the intercept and/or the slope and the intercept.

[6] It turned out that the results of the Phillips curve when we twice differenced the price level do not make sense in terms of the signs and the magnitudes of the coefficients.

We estimate two specifications of the forward-looking Phillips curve. In the first, inflation depends on $E_t \pi_{t+1}$ and the log of unemployment rate, where the former is an unobservable variable. In the second specification, we use the unemployment gap as a regressor. In this case, both explanatory variables are unobservable. All Phillips curves with forward-looking specifications will be estimated using GMM (Generalized Method of Moments).[7] The residuals of these specifications will be diagnosed using the Durbin's Cumulated Periodogram test in the frequency domain.[8] We are convinced that the foreign inflation rates can be considered strictly exogenous to Hong Kong because Hong Kong cannot influence inflation rates in China and the US.[9] The coefficient of $E_t \pi_{t+1}$ is not statistically different from one and the diagnostics of the residuals are good. These results are consistent with those reported by Ha and Leung (2001) although they used the output gap instead of the unemployment gap.

We now estimate the mark-up model of Whelan (1999). Productivity will affect price dynamics if it affects real wages.[10] We measure the level of labour productivity as real GDP per employed person.[11] Figure 5 plots labour productivity and the output fluctuations over the business cycle. These two variables co-move over the business cycle.

Figure 6 plots the business cycle fluctuations of real GDP and employment, the two components of labour productivity. During the period 1997 onwards, real GDP fell by much more than employment, thus productivity fell sharply. Labour productivity seems procyclical. The real unit labour cost (share of labour) is $W_t L_t / P_t Y_t$. The mark-up of price over unit labour cost is the inverse, which is $P_t Y_t / W_t L_t$. Labour productivity Y_t / L_t fell because real GDP fell by more than employment. The price level, whether the CPI or the GDP deflator, fell by more than nominal wages. We suspect that the degree of wage stickiness is higher than price stickiness. It is probably important that we understand the nature of wage stickiness in Hong Kong. Figure 7 (7a, 7b and 7c) plots three measures of real wages and labour productivity. The level of the real wage rate has almost always been below measured labour productivity,

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7 There are two specifications, one includes the level of unemployment as an explanatory variable, and the other model includes the unemployment gap. We use the following instruments in the unemployment level regression: two lags of inflation in China, second to fourth lag of inflation in the US, four lags of nominal wage growth rate, first, second and fourth lag of average property prices growth rate, which is the average of the growth rates of four prices: housing, factory space, retail space and office space. We also have the third and fourth lags of unemployment, a constant term and trend as instruments. These instruments are not correlated with the residuals from the Phillips curve; R^2 is 0.18. In the gap model, we used the first and the second lags of inflation in China, and the second, the third and the fourth lag of inflation in the US. We used four lags of nominal wage growth rate, and the first, the second and the fourth lag of the average property-prices growth rate defined above. We also have the first, the third and the fourth lag of the unemployment gap. The reason that some lags were removed from the instruments' list is because they were found to be correlated with the residuals of the Phillips curve. The remaining instruments were not correlated with the residuals. The R^2 is 0.25.

8 The statistic is the Kolmogrov-Smirnov. This test is non-parametric and it does not rely on assumptions regarding the specification of the regression, linear or non-linear like the Durbin-Watson test. It tests the null hypothesis that the residuals are white noise.

9 The inclusion of redundant instrument leads to deterioration in the finite sample properties of the GMM estimator. Hall (2003) provides canonical correlations information criteria to select instruments that are both orthogonal and non-redundant (relevant). We have checked whether the residuals are correlated with the instruments and eliminated those instruments that are highly correlated with residuals to ensure orthogonality. We believe that our instruments are relevant. Formal testing is not carried out because our sample is very short.

10 Blanchard and Katz (1999) present a model where the real wage does not depend on labour productivity.

11 It made very little difference when we used working-age population (15-64) instead of employment. Data on hours worked are not readily available.

except for the last couple of years (sample ends in 2001). If the real wage exceeds productivity, the denominator $\frac{W_t}{P_t}/\frac{Y_t}{L_t}$ increases and its inverse, the mark-up, falls.

Figure 8 (8a, 8b, 8c and 8d) plots the quarterly CPI inflation rate and three measures of mark-up. Wages are measured by total compensation. The number of people employed is L, P is the GDP deflator, and Y is real GDP. The second measure replaces the GDP deflator with the CPI, and the third uses nominal GDP minus indirect taxes as Rotemberg and Woodford (1999) have suggested. We finally plot the mark-up as the inverse of the labour share, which is average payroll times the total number of employed people to nominal GDP ratio.

This model suggests that if the mark-up falls because of unexpected shocks then a combination of falling prices, rising nominal wages and lower labour productivity is required to restore equilibrium. If wages are sticky, and productivity does not decelerate enough, prices have to fall to keep the mark-up down.

Estimation of equation (11) should tell us whether the price mark-up over unit labour is an important determinant of inflation, conditional on all other variables such as labour productivity and unemployment. The equation, however, has some econometric problems. First, the time series properties of the variables entering this equation are ambiguous (see appendix 2 for unit root tests). We are not sure whether the CPI inflation has one or two unit roots. If productivity is not stationary, as our tests indicate, then our estimation requires some restrictions on the coefficients. Whelan imposes the restriction $\gamma_1 - 1 = -(\gamma_2 + \rho)$, which implies that Δq_t enters in the equation instead of q_t. All tests indicate that the mark-up has a unit root except the DF-GLS tests, which suggest that the mark-up is stationary. Second, the equation suffers a single-equation bias (endogeneity), which becomes problematic in the presence of wage rigidity. Unexpected shocks to wages have a temporary effect on reducing the mark-ups. If the shocks are serially correlated then μ_{t-1} will be negatively correlated with ζ_{t-1} and with ζ_t, which puts a downward pressure on the estimate of ρ.

Whelan (1999) estimated equation (12), i.e., the wage equation only. Then he used some variables, such as oil prices, to proxy supply shocks to identify ρ. We do not follow this estimation strategy. Instead we estimate the system of the two equations simultaneously and test the cross-equation restrictions. The system that we estimated is given by:

$$\pi_t = \eta\pi_{t-1} + \alpha + \rho_1\mu_t - \rho_2\mu_{t-1} + (\gamma_1 - 1)\Delta q_t - \beta\tilde{u}_t + v_t \quad (17)$$

$$\Delta w_t = \eta\pi_{t-1} + \alpha + (1-\rho_2)\mu_{t-1} + \gamma_1\Delta q_t - \beta\tilde{u}_t + v_t \quad (18)$$

Again, $\pi = \Delta p_t$ is the quarterly CPI inflation rate and $\tilde{u}_t$ is the unemployment gap defined earlier.[12] The mark-up is measured as the inverse of the share of labour. Productivity q_t, is log real GDP to employment ratio. The unemployment used in this regression is the gap measured using the Band-Pass filter for frequencies between 6-32 quarters in length. Lowercase means the variable is measured in log.

12 The assumption is that workers bargain over real wages defined relative to a consumption price index, which includes both domestic and foreign goods and services in a small open economy like Hong Kong.

In Whelan (1999) and in equations (16) and (17) lagged mark-up, μ_{t-1}, has a coefficient, ρ that needs to be estimated. The contemporaneous mark-up, which only enters the price equation, has no coefficient, i.e. one. We estimate four regressions. The first set is when the coefficient of the contemporaneous mark-up, ρ_1 is not estimated, i.e., set equal to one. Under this assumption we estimate the system twice: once when inflation expectations are backward (i.e., the regressor is π_{t-1}) and then when they are forward (i.e., the regressor is π_{t+1}). Then we estimate the system including ρ_1. The method of estimation is GMM. The instruments are four lags of: the US CPI inflation, China's CPI inflation, average property price inflation, which is the average of four growth rates of four prices: private property, office space, factory space, and retail space. We also have four lags of: nominal wage growth rate, productivity growth, the output gap and a constant term. The results are reported in table 4a.

There are two panels in table 4a. The first panel lists the results of the estimation when ρ_1 is not estimated (a value of one is imposed) and when expectations are backward and forward looking. In the second panel, we report the results when ρ_1 is estimated freely. In the first panel, the coefficient of lagged mark-up, ρ_2 , is positive and close to one in magnitude. The coefficient 0.89 suggests that permanent shocks to the mark-up affect price inflation for many periods in the future because workers who bargain over their productivity-adjusted real wages do not incorporate all the information about the shock in their bargaining (they would have if ρ_2 was one). Thus, they do not adjust fully to the shock, and the shock affects CPI inflation in subsequent periods following the shock. The estimate of γ_1, which measures the effect of productivity on inflation, is 0.39, and has the correct sign (recall that the coefficient is $\gamma_1 - 1$ so the effect of productivity on inflation is negative, as expected). The coefficient 0.39 also means that the effect of productivity on wages is much larger than the effect on prices. All other coefficients have the right signs and magnitudes. The diagnostics indicate that the residuals are white noise. No significant differences are detected in the estimated coefficients of the forward-looking specification.

When we estimate ρ_1 from the data, we find that ρ_1 is negative, but ρ_2 remains positive. Whelan (1999) reported a change of signs (simultaneity bias).[13] We do not find a change in signs. The magnitude of ρ_2 is slightly smaller than before, 0.77 and 0.78 for backward and forward looking specifications respectively. Nevertheless, ρ_2 is still larger in magnitude than ρ_1. The increase in the mark-up is associated with an immediate decline in inflation and a subsequent increase in the next period.

The estimates of γ_1 are 0.69 and 0.64 for the backward and the forward-looking specifications respectively. They suggest that the effect of productivity on wages is smaller than the effect on prices. At any rate, productivity seems to have a significant effect on prices and wages in Hong Kong in excess of what the mark-ups and unemployment have. It would be informative to examine whether or not productivity in Hong Kong has increased in the last decade following the handover to China. Unemployment has the right sign in the first set and the incorrect sign in the second regardless of

13 The model is derived under then assumption that there is no correlation between the leads and lags of μ_t and v_t. This assumption could be violated if there were some price rigidity, such that the unexpected shocks to wages have a temporary effect in eroding mark-ups. If such shocks are uncorrelated, then μ_{t-1} will be negatively correlated with v_{t-1} and v_t leading to downward biased estimates of ρ_2.

whether we use log unemployment or the unemployment gap.[14] In sum, the mark-up model does not seem to work well when we try to estimate separate coefficients for the time-varying mark-up terms.

Table 4b reports the tests of the restrictions implied by the model. We estimated the system with backward and forward-looking inflation expectations; under each, ρ_1 is once imposed equal to one and then estimated from the data. We find support for the model when expectations are backward and when ρ_1 imposed equal to one. Only two restrictions fail to hold: that the coefficient of π_{t-1} is equal to one in both equations, and the restriction on labour productivity. However, none of the restrictions hold when we estimate ρ_1 from the data and the model's performance deteriorates remarkably.

To estimate the Gali-Gertler's specification of the Phillips curve we follow the authors and assume that the production function is a Cobb-Douglas:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{19}$$

In equation (19), Y_t is real output, A_t is technology, K_t is physical capital and L_t is labour. If capital is assumed fixed in the short run, the real cost is the ratio of the wage rate to the marginal product of labour:

$$MC_t = (W_t / P_t)(\partial Y_t / \partial L_t) \tag{20}$$

The level of the wage rate is W_t, P_t is the price of output and $\partial Y_t / \partial L_t$ is the marginal product of labour. Let $S_t = W_t L_t / P_t Y_t$ be the unit labour cost, where the product $W_t L_t$ measures the level of compensations to employees. The denominator is nominal GDP. In percent deviations from steady state, log unit labour cost $s_t = mc_t$, i.e., real marginal cost.

In logs, the New Phillips curve is given by:

$$\pi_t = \lambda mc_t + \tilde{\rho} E_t \pi_{t+1} \tag{21}$$

And the equation we estimate is:

$$\pi_t = \frac{(1-\theta)(1-\tilde{\rho}\theta)}{\theta} \widetilde{mc}_t + \tilde{\rho} E_t \pi_{t+1} + \xi_t \tag{22}$$

We tried both the CPI inflation and the GDP deflator inflation when estimating this model, but we only report the CPI regressions because the deflator does not seem to fit well, GMM takes a much longer time to converge and the estimation is sensitive to the choice of the instruments. The real unit labour cost is measured using the total compensation to employees to nominal GDP ratio, and the deviation of the marginal cost from steady state is basically the cyclical fluctuations of the marginal cost.[15] We used

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14 We also estimated the model where inflation enters in the first difference instead of the level. The results are not reported, but they are available upon request. We found that the estimated ρs are slightly larger and closer to one. The coefficient η is much smaller than one, β and γ_1 did not change. These results do not alter the interpretation of the model.

15 We use the Approximate Band Pass filter to measure the business cycle fluctuations that are between 6-32 quarters in periodicity.

GMM, where $E_t[(\pi_t - \frac{(1-\theta)(1-\tilde{\rho}\theta)}{\theta} m\tilde{c}_t - \tilde{\rho}\pi_{t+1}, \Phi)] = 0$, and the vector Φ includes variables dated $t-1$ to $t-k$, which are orthogonal to inflation's surprise in the period. So, we estimate the structural parameters directly, i.e., we estimate θ and $\tilde{\rho}$. The instruments are four lags of: the US CPI inflation, China's CPI inflation, average property price inflation, which is the average of four growth rates of four property prices: private property, office space, factory space, and retail space. We also have four lags of the nominal wage growth rate, and the unemployment gap. The results are reported in table 5. We also compare the estimates for Hong Kong with those for the US reported in Gali and Gertler (1999).

The CPI inflation's specification fits the data well. The estimated coefficients of the CPI equation are very robust to any set of instruments.[16] The estimate of θ in the CPI equation is 0.83, which is not different from the US estimate and a little higher from those reported in Genberg and Pauwels (2003) for Hong Kong.[17] The coefficient θ is an estimate of the probability that firms do not adjust prices. It implies that prices remain fixed for about a year and a half, *on average*. Given our estimated standard errors, the $\pm\ 2\sigma$ interval implies that adjustment takes approximately 4 to 12 quarters (1 to 3 years). This is our estimate of price rigidity. Gali and Gertler (1999) argue that the estimate of price rigidity is probably biased upwards because unit labour cost is just a proxy for the real marginal cost; the sample is small and the assumption is that the mark-up is constant. The estimates of the subjective discount factor are $\tilde{\rho}$ = 0.98. The residuals are white noise.

We report the out-of-sample forecasts of all the models. The aim of this exercise is merely to provide an additional diagnostic. For a sample up to December 1997, we re-estimated each of model (5) and (7) (the Phillips curves) using both the level and the gap of unemployment. We also re-estimated the system of equations (17) and (18), with forward-looking and backward-looking expectations with and without the restrictions that ρ_1 = 1. Finally we estimated the Gali-Gertler model, i.e., equation (22). In all these regressions we use CPI inflation rather than the deflator. Static forecasts for the period March 1998 to December 2001 were computed. This is equivalent to a one-step forecast.[18] For the system of equations, we solved the model and computed both static and dynamic simulations over the period March 1999 to December 2001. Figure 9 (a, b, c and d) plots the out-of-sample forecasts. In terms of RMSE, the traditional specification of the Phillips curve with lagged inflation and log unemployment produces the worst out-of-sample forecast. The second worst forecasts are obtained from the system of equations. The forecasts for the first few quarters were reasonable, but the forecast becomes very volatile halfway through the period. The forecasts are bad because the restrictions do not hold and because there are many parameters to estimate. The Phillips curve, with forward-looking inflation and the unemployment gap estimated by GMM and the Gali-Gertler model, produces reasonably good forecasts of CPI inflation.[19] The average of these two models has better properties.

16 Genberg and Pauwels (2003) report some sensitivity to their instruments in their regressions.

17 We are not sure whether Genberg and Pauwels (2003) estimated the structural parameters directly like we did here or they computed the implied structural parameters.

18 This is not a rolling forecast.

19 The RMSE and the Theil's inequality are: 0.0078 and 0.34, 0.009 and 0.47, 0.0099 and 0.42, and 0.006 and 0.35 for the three Phillips curve specifications that we estimated and the Gali-Gertler New Phillips curve respectively.

Gali and Gertler (1999) argued that if the mark-ups (inverse of unit labour cost) were countercyclical, the implied estimate of price rigidity would be lower. With a countercyclical mark-up, the desired price setting is less sensitive to movements in real marginal cost. However, it is rather difficult to pin down the cyclical pattern of the real marginal cost and the mark-up.[20] The cyclical pattern of the mark-up is determined by many factors, among them the nature of the shocks, e.g., a technology shock, which are difficult to identify.

Rotemberg and Woodford (1999) argue that it is likely that the share of labour rises late in expansions and falls late in recessions. They tried several different measures and reported cross-correlation functions. They found that in the US data, business cycle fluctuations of real GDP are correlated negatively with the leads of the share of labour, and positively with the lags. We find somewhat similar patterns of correlation in the Hong Kong data, but depending on how the share of labour is measured. In Hong Kong, the cyclical fluctuations of real GDP and the labour share suggest they are negatively correlated at almost all leads and also contemporaneously, but GDP is positively correlated with all lags of unit labour cost. If indeed the share of labour falls late in the recession, then in Hong Kong there are still more adjustments to be made because output has declined at rates faster than employment. [21]

We examine the nominal wage, the price level, real output and the employment, which constitute unit labour cost. The descriptive statistics of the rates of change of these variables over two, arbitrarily chosen, sub-samples that are meant to represent the period before and after the recent deflationary episodes in Hong Kong are reported in table 6.

The Student t statistics to test the hypothesis that the means remained unchanged over the two sub-samples reject the null hypothesis for all variables, except for employment. Employment did not fall significantly. The magnitudes of fall in prices exceed those in wages, and the fall in real output exceeds that in employment. Therefore, the real wage has increased and productivity has declined. If prices are falling faster than the rate of productivity growth, nominal wages must be cut to lower real wages. As a result, the labour share of income or unit labour cost may rise. Instead of clearing in price (wage rate), the labour market may clear in quantity (hours or employment), resulting in some combination of higher measured unemployment (still increasing) and lower participation rates (significant decline). The danger is a rising real wage and falling employment until wages are finally ground down in a long and painful process. There seems to be some rigidity in the labour market.

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20 See Rotemberg and Woodford (1999) for detailed examination of the US data.

21 The cross correlation functions of real GDP's deviations from trend (BP filtered data), and the share of labour (BP filtered) for the period 1986-2001 are: lead 1 (0.37), lead 2 (0.31), lead 3 (0.20), lead 4 (0.03), lead 5 (-0.17), lead 6 (-0.37), lead 7 (-0.53), lead 8 (-0.61), contemporaneously (-0.60), lag 1 (-0.44), lag 2 (-0.25), lag 3 (-0.05), lag 4 (0.13), lag 5 (-0.28), lag 6 (0.26), lag 7 (0.33), and lag 8 (0.25).

Preliminary investigation seems to suggest that there is considerable real wage (not in quantities such as employment and unemployment, but in prices) rigidity in Hong Kong. We found that the estimated response of wages, conditional on expected inflation, to excess supply of labour (measured as the deviation of unemployment from its natural rate or the unemployment gap) is rather small. If we interpret this estimate as a measure of flexibility then the inverse can be interpreted as a measure of wage rigidity. Wage rigidity depends on many factors such as the type of prevailing labour contracts, the degree of wage indexations, monetary policy arrangements and cultural and institutional factors. Real wage rigidity needs to be formally tested and the underlying reasons behind it and its implications must be understood. Future research should also compare the estimated wage rigidity in Hong Kong with other countries like the US, where wage rigidity is high compared with Japan, for example.

4. Summary and conclusions

We investigated the sources of deflation in Hong Kong. Examination of the data suggested to us that the currency board and the Asian crisis are *probably not the main* drivers of deflation. The exchange rate regime has been in place since the early 1980s but the deflation occurred four years ago. Therefore, it is very difficult to argue that the exchange rate regime is the driving force of deflation in Hong Kong even though we would expect prices to move around a lot more when the exchange rate is fixed. As for the Asian crisis, figures 2 and 3 show that major asset prices started to fall early in the 1990s and not in 1997 or 1998, therefore, it is again very difficult to argue that the Asian crisis is the driving force of the recent deflation. We test two hypotheses regarding deflation in Hong Kong.

We tested two related hypotheses, both of which are based on optimal decision making by economic agents. First, we tested the hypothesis that the prices have been falling because economic agents had expected, as early as the mid 1990s, that future marginal costs would fall to levels equivalent to those of China. That was entirely based on the anticipation of China assuming sovereignty over the territory in 1997. Factory and office space prices gave early signals. They started to fall in the mid 1990s and never recovered. Private property and retail space prices started to fall immediately following the Asian crisis. The second related hypothesis is that the mark-ups over marginal costs have fallen, “causing” falling prices. The main objective of this paper was to investigate the adjustment process of wages and prices and to try to estimate the period of time required for the price adjustment to be complete. The adjustment process is influenced by the assumptions regarding price-wage flexibility and the formations of expectations. Therefore, questions regarding the forwardness of expectations’ formations and the degree of price adjustment were the main questions raised in this paper.

The traditional Phillips curve is the maintained model for inflation, but a single-equation reduced-form Phillips curve could not answer our questions regarding the adjustment process because it would not allow us to place testable restrictions on structural parameters. For this reason, we estimated, in addition to the traditional Phillips curve, two other structural Phillips curves. We estimated the Phillips curve version of Rotemberg and Woodford (1999) and derived in Whelan (1999), where inflation is driven mainly by mark-up over marginal cost. And, we estimated the New Phillips curve, where inflation is driven by the real marginal cost (Gali-Gertler, 1999). Our estimates of the structural parameters of the New Phillips curve suggest that price setting in Hong Kong exhibits a large degree of forwardness. Our estimate of the degree of price stickiness (Calvo's probability of price change) is also reasonable. Given our small sample, we found this parameter to be 0.86 with a standard error equal to 0.05. Thus, on average it takes prices 4 quarters to adjust fully, the standard errors around that suggest that it might take between a minimum period of approximately 4 quarters and a maximum of 12 quarters.

The mark-up over marginal cost is assumed to be time varying. Essentially, it is measured as the inverse of the unit labour cost or the share of labour. It is assumed that this is measured by the productivity-adjusted real wage. During recessions, measured labour productivity (output per worker) in Hong Kong fell because output fell faster than employment. The aggregate real wage did not fall by the same amount because the aggregate nominal wage remained flat for several years while the price level continued to fall. However, the real wage is catching up with productivity.

The relationship between the mark-up and price dynamics is less than one to one. The estimated coefficient, which is the parameter that governs the degree of persistence of real wages, turned out to be less than one, but much bigger than zero. It is estimated to be 0.89. This parameter suggests that permanent shocks to the mark-up induce workers who bargain over their productivity-adjusted real wage to slowly adjust to the shock rather than fully adjusting. Therefore, shocks to the mark-up affect price dynamics for several subsequent periods following the shock. The parameter estimate from this system of wage-price dynamics is almost the same as the estimated parameter of price stickiness in the Gali-Gertler model and to that in Whelan (1999) for the United States. Labour productivity itself plays a significant role in explaining wage-price dynamics. The two specifications of the Phillips curve: when inflation expectations are assumed forward-looking and the unemployment gap is used instead of the level, and the Gali-Gertler model, produce very good out-of-sample forecasts of CPI inflation. Finally, we found significant evidence that suggests real wage rigidity is high in Hong Kong.

Preliminary investigation suggests that there is significant real wage rigidity in Hong Kong and that unit labour cost is an important variable to explain price dynamics in Hong Kong. Therefore, we might need to further examine wage rigidity and the dynamics of unit labour cost. Disaggregated wage data might provide some explanations that we could not find in aggregated data.

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Table 1. Sample 1986:1 - 2001:4

OLS Estimates						
π_t	=	0.006	+	0.78 π_{t-1}	-	0.004 u_t
		(0.002)		(0.071)		(0.001)
$\overline{R}^2$	0.82					
DW	2.1					
σ	0.005					

Stability tests		
	F - test	P value
Chow break point 1994:4	0.6475	0.5876
Chow forecast 1994:4-2001:4	1.0893	0.4050
Ramsey RESET (1)	0.2074	0.6504

Standard errors are in parentheses.
When the long-run neutrality is imposed, the regression is written as follows:

$$\pi_t = \alpha_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi_{t-3} + (1-\delta_1-\delta_2-\delta_3)\pi_{t-4} + \beta\, u_t$$

Table 2. Sample 1987:1 - 2001:4

GMM Estimates						
π_t	=	0.003	+	0.88 $E_t\pi_{t+1}$	-	0.002 u_t
		(0.001)		(0.04)		(0.001)
$\overline{R}^2$	0.78					
DW	2.06					
J	0.14					
σ	0.005					
Durbin's Cumulative Periodogram	0.17					

- Standard errors are in parentheses.
- The instruments are two lags of the inflation in China, second to fourth lag of inflation in the US, four lags of nominal wage growth rate, first, second and fourth lag of average property prices growth rate, which is the average of the growth rates of housing price, factory space, retail space and office space prices, third and fourth lags of unemployment, a constant term and trend. These instruments are not correlated with the residuals from the Phillips curve. The R^2 is 0.18.
- The J statistic is Hansen's test for over-identifying restrictions for the instruments, distributed χ^2.
- We used simultaneous weighting matrix and coefficient iterations. The Newey-West method is used to estimate the variance-covariance matrix. The Kernel is Bartlett. The bandwidth is fixed, and pre-whitening is also applied. Convergence is achieved in 29 iterations.
- The Durbin's Cumulative Periodogram is the Kolmogrov-Smirnov statistics to test the null hypothesis that the residuals are white noise. The 5 per cent critical value is 0.36.
- We test whether the coefficient of $E_t\pi_{t+1}$ is equal to one. The P value of the Wald statistic is 0.01.

Table 3. Sample 1987:1 - 2001:4

GMM Estimates

π_t	=	-0.0005	+	1.0 $E_t\pi_{t+1}$	-	0.003 $\tilde{u}_t$
		(0.0004)		(0.025)		(0.001)
$\overline{R}^2$	0.78					
DW	2.2					
J	0.13					
σ	0.005					
Durbin's Cumulative Periodogram	0.23					

- Standard errors are in parentheses.
- We use the following instruments. We used the first and the second lags of inflation in China, and the second, the third and the fourth lag of inflation in the US. We used four lags of nominal wage growth rate, and the first, the second and the fourth lag of the average property-prices growth rate, which is the average of the growth rates of housing price, factory space, retail space and office space prices, a constant term and trend. In the unemployment gap regression we used the first, the third and the fourth lag of the unemployment gap. In the Phillips curve, where the level of unemployment is used instead of the gap, we used lags of the unemployment level as instruments. Finally, the instruments included trend and a constant term. The reason that some lags were removed from the instruments' list is because they were found correlated with the residuals of the Phillips curve. The remaining instruments were not correlated with the residuals. The R^2 is 0.25.
- The J statistics is Hansen's test for over-identifying restrictions of the instruments, distributed χ^2.
- We used simultaneous weighting matrix and coefficient iterations. The Newey-West method is used to estimate the variance-covariance matrix. The Kernel is Bartlett. The bandwidth is fixed and pre-whitening is also applied. Convergence is achieved in 12 iterations.
- The Durbin's Cumulative Periodogram is the Kolmogrov-Smirnov statistics to test the null hypothesis that the residuals are white noise. The 5 per cent critical value is 0.36.
- We test whether the coefficient of $E_t\pi_{t+1}$ is equal to one. The P value of the Wald statistic's P value is 0.94.

Table 4a. GMM estimates of a system of the mark-up equations

$$\pi_t = \eta\pi_{t-1} + \alpha + \rho_1\mu_t - \rho_2\mu_{t-1} + (\gamma_1 - 1)\Delta q_t - \beta\tilde{u}_t + v_t$$
$$\Delta w_t = \eta\pi_{t-1} + \alpha + (1-\rho_2)\mu_{t-1} + \gamma_1\Delta q_t - \beta\tilde{u}_t + v_t$$

	θ =1, not estimated				χ_1^2 is estimated directly			
	$k=1$ (Backward looking)		$k=-1$ (Forward looking)		$k=1$ (Backward looking)		$k=-1$ (Forward looking)	
CPI	**Estimate**	**STD**	**Estimate**	**STD**	**Estimate**	**STD**	**Estimate**	**STD**
η	0.73	0.035	0.66	0.015	0.60	0.030	0.67	0.046
α	0.29	0.029	0.44	0.008	0.60	0.018	0.56	0.015
ρ_1	-	-	-	-	-0.54	0.013	-0.57	0.011
ρ_2	0.89	0.010	0.83	0.003	0.77	0.006	0.78	0.006
γ_1	0.39	0.010	0.35	0.011	0.69	0.017	0.64	0.014
β	-0.004	0.0002	-0.0009	0.0002	0.001	0.0002	0.003	0.0003
Determinant of residuals covariance	0.00		0.00		0.00		0.00	
J	0.28		0.29		0.27		0.27	
Durbin's Cumulative Periodogram								
CPI equation	0.28		0.27					
Wage equation	0.09		0.17					
DW								
CPI equation	2.2		2.1		2.1		2.2	
Wage equation	1.8		1.5		1.6		1.6	
σ								
CPI equation	0.02		0.02		0.02		0.02	
Wage equation	0.01		0.01		0.01		0.01	

- The instruments are four lags of the following variables: the CPI inflation, average property prices growth rate, which is the average of the growth rates of housing price, factory space, retail space and office space prices, wage growth, productivity growth, trend and a constant term. We used The Newey-West method to estimate the variance-covariance matrix. We used simultaneous weighting matrix and coefficient iterations. The Kernel is Bartlett. The bandwidth is fixed, and pre-whitening is also applied.
- The J statistics is Hansen's test for over-identifying restrictions of the instruments, distributed χ^2.
- Durbin's Cumulative Periodogram test is the Kolmogrov-Smirnov statistic for testing the null hypothesis. The residuals are white noise. The 5 per cent critical value is 0.36.

Table 4b. P values of testing the restrictions implied by the mark-up model

$$\Delta p_t = a_{11}\Delta p_{t-k} + a_{12} + a_{13}\mu_t + a_{14}\mu_{t-1} + a_{15}\Delta q_t + a_{16}\tilde{u}_t + \zeta_t$$
$$\Delta w_t = a_{21}\Delta p_{t-k} + a_{22} + a_{23}\mu_{t-1} + a_{24}\Delta q_t + a_{25}\tilde{u}_t + \zeta_t$$

CPI		**a_{13} =1, not estimated**		**a_{13} is estimated directly**	
		Backward $k=1$	**Forward** $k=-1$	**Backward** $k=1$	**Forward** $k=-1$
		P Values			
$a_{11} = a_{21}$	χ_1^2	[0.2157]	[0.0001]	[0.0382]	[0.0016]
$a_{11} = a_{21} = 1$	χ_2^2	[0.0017]	[0.0001]	[0.0954]	[0.0003]
$a_{12} = a_{22}$	χ_1^2	[0.0514]	[0.0001]	[0.0415]	[0.0001]
$a_{12} = a_{22}$	χ_1^2	-	-	[0.0001]	[0.0001]
$a_{23} = 1 - a_{14}$	χ_1^2	[0.0483]	[0.0001]	[0.0001]	[0.0001]
$a_{15} = a_{25} - 1$	χ_1^2	[0.0006]	[0.0001]	[0.0001]	[0.0001]
$a_{15} = a_{25}$	χ_1^2	[0.4716]	[0.6791]	[0.0001]	[0.0001]

Table 5: GMM Estimates of the New Phillips curve

$$\pi_t = \lambda mc_t + \tilde{\rho} E_t \pi_{t+1}$$
$$E_t[(\pi_t - \lambda m\tilde{c}_t - \tilde{\rho}\pi_{t+1}, \Phi)] = 0$$
$$\lambda = \frac{(1-\theta)(1-\tilde{\rho}\theta)}{\theta}$$

	Hong Kong 1987:1 - 2001:4				US 1960:1 - 1997:4		
	θ	$\tilde{\rho}$	λ		θ	$\tilde{\rho}$	λ
CPI	0.83	0.98	0.026	NFB Deflator	0.83	0.96	0.038
	(0.045)	(0.01)	(0.018)		(0.015)	(0.018)	(0.008)
σ	0.005						
J	0.20						
				GDP Deflator	0.83	0.92	0.047
					(0.013)	(0.024)	(0.008)
Durbin Cumulative Periodogram	0.23						

- Standard errors are in parentheses. For instruments we used four lags of the following variables: the unemployment gap, CPI inflation in China, CPI inflation in the US, average property prices growth rate, which is the average of the growth rates of housing price, factory space, retail space and office space prices, and wage growth. The Newey-West method to estimate the variance-covariance matrix is used and simultaneous weighting matrix and coefficient iterations. The Kernel is Bartlett. The bandwidth is fixed, and pre-whitening is also applied. Convergence is achieved in 13 iterations. NB is non-farm US value-added deflator.
- J is the over-identifying restrictions' test.
- Durbin's Cumulative Periodogram is the Kolmogrov-Smirnov statistic to testing the null hypothesis that the residuals are white noise. The 5 per cent critical value for the Durbin Cumulative Periodogram test is 0.36.

Table 6. Descriptive Statistics

	Mean	STD	Minimum	Maximum
1985:1 - 1997:1				
Nominal wage[1]	0.032	0.026	-0.002	0.131
Nominal wage[2]	0.029	0.011	-0.001	0.056
CPI	0.018	0.007	0.001	0.035
GDP deflator	0.017	0.009	-0.013	0.047
Real GDP	0.015	0.033	-0.105	0.138
Employment	0.004	0.006	-0.011	0.016
Participation rate	-0.001	0.004	-0.010	0.007
1997:2 - 2001:4				
Nominal wage[1]	0.004	0.012	-0.010	0.028
Nominal wage[2]	0.002	0.007	-0.014	0.013
CPI	-0.002	0.009	-0.018	0.015
GDP deflator	-0.006	0.011	-0.021	0.017
Real GDP	0.004	0.022	-0.039	0.052
Employment	0.001	0.007	-0.012	0.015
Participation rate	-0.00005	0.003	-0.005	0.008

- 1 is total compensation to employee.
- 2 is payroll wage.
- All variables are measured in log difference.

Figure 1. CPI Quarterly Inflation Rate

Figure 2. Log prices of private property, office, retails and factory space index in Hong Kong

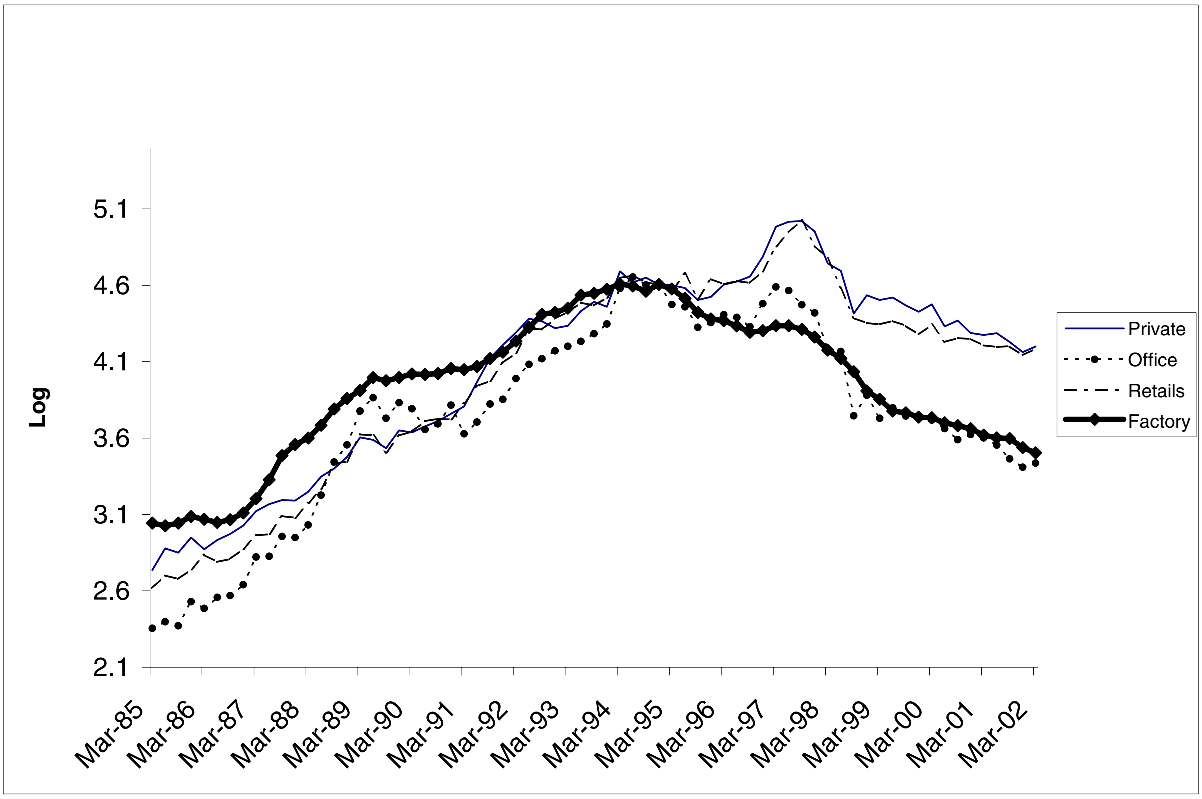


Figure 3. Log Relative Prices

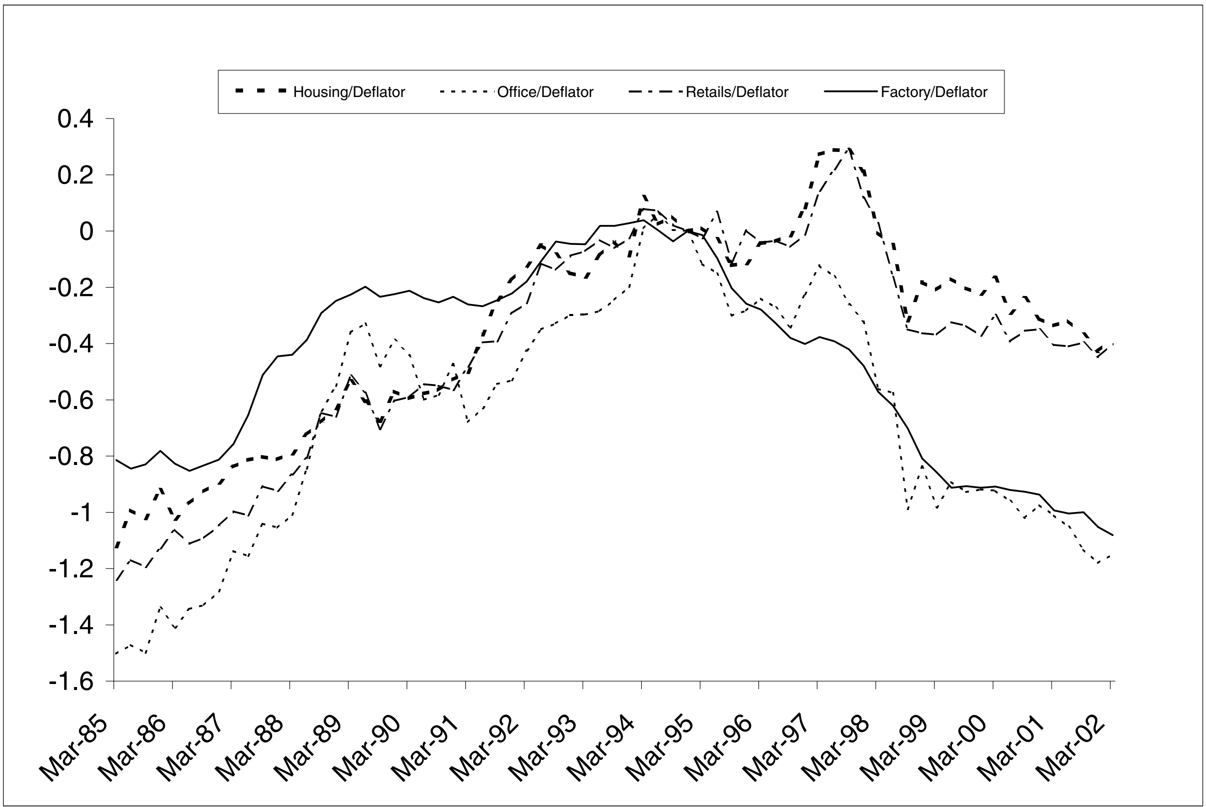


Figure 4a. The Wage-Unemployment Relationship (85-02)

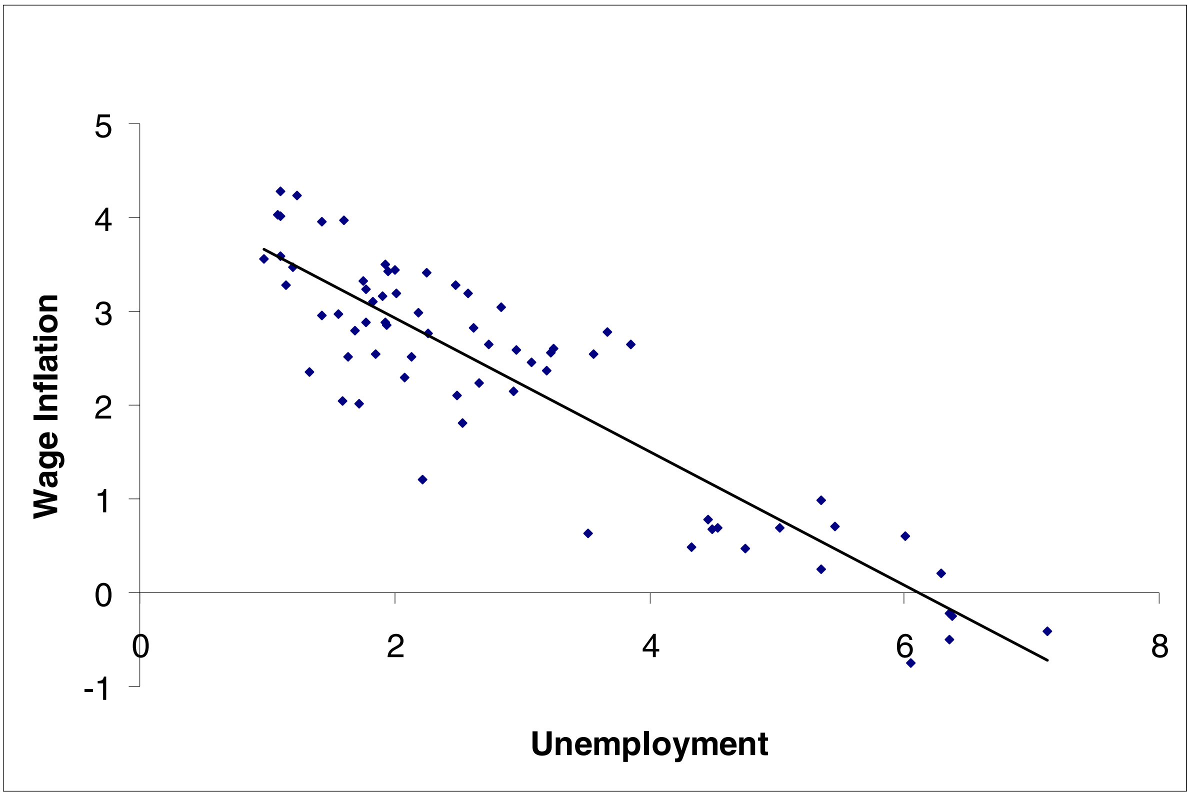


Figure 4b. Wage growth-Expected Inflation – Unemployment (85-02)

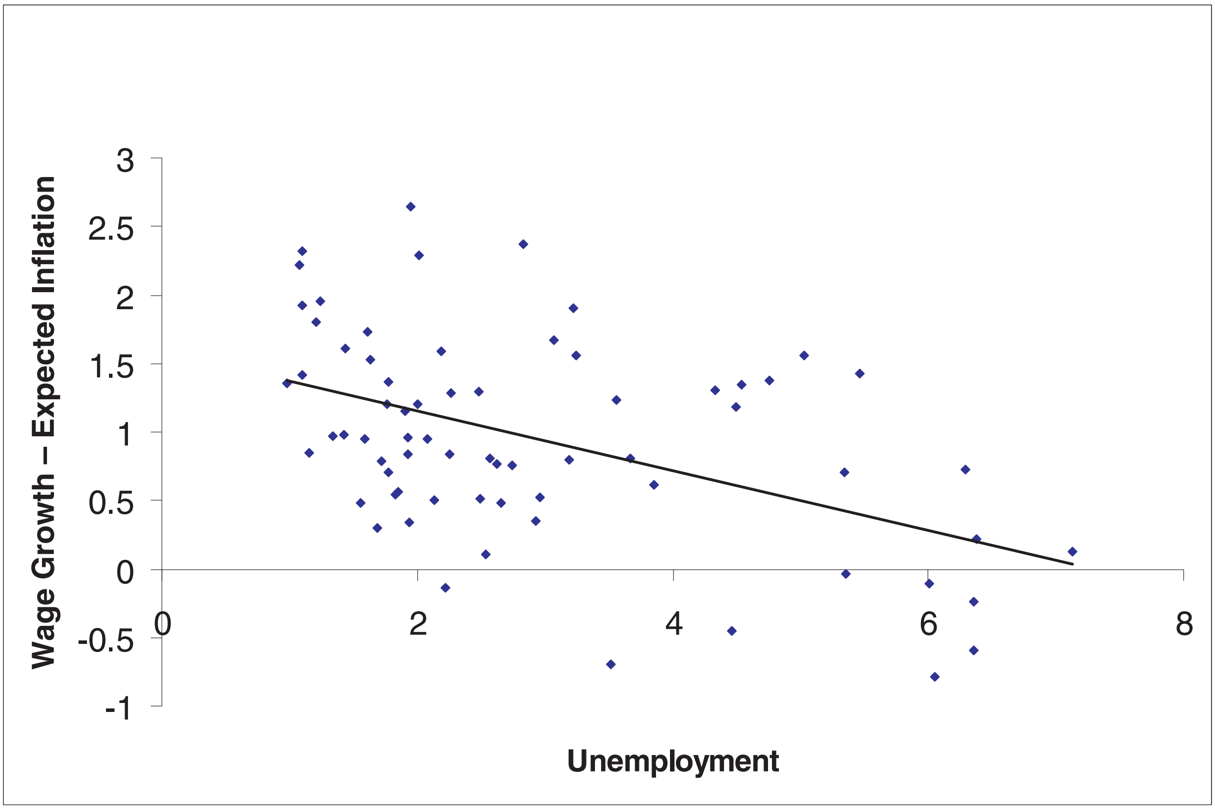


Figure 4c. Real Wage Growth and Unemployment (85-02)

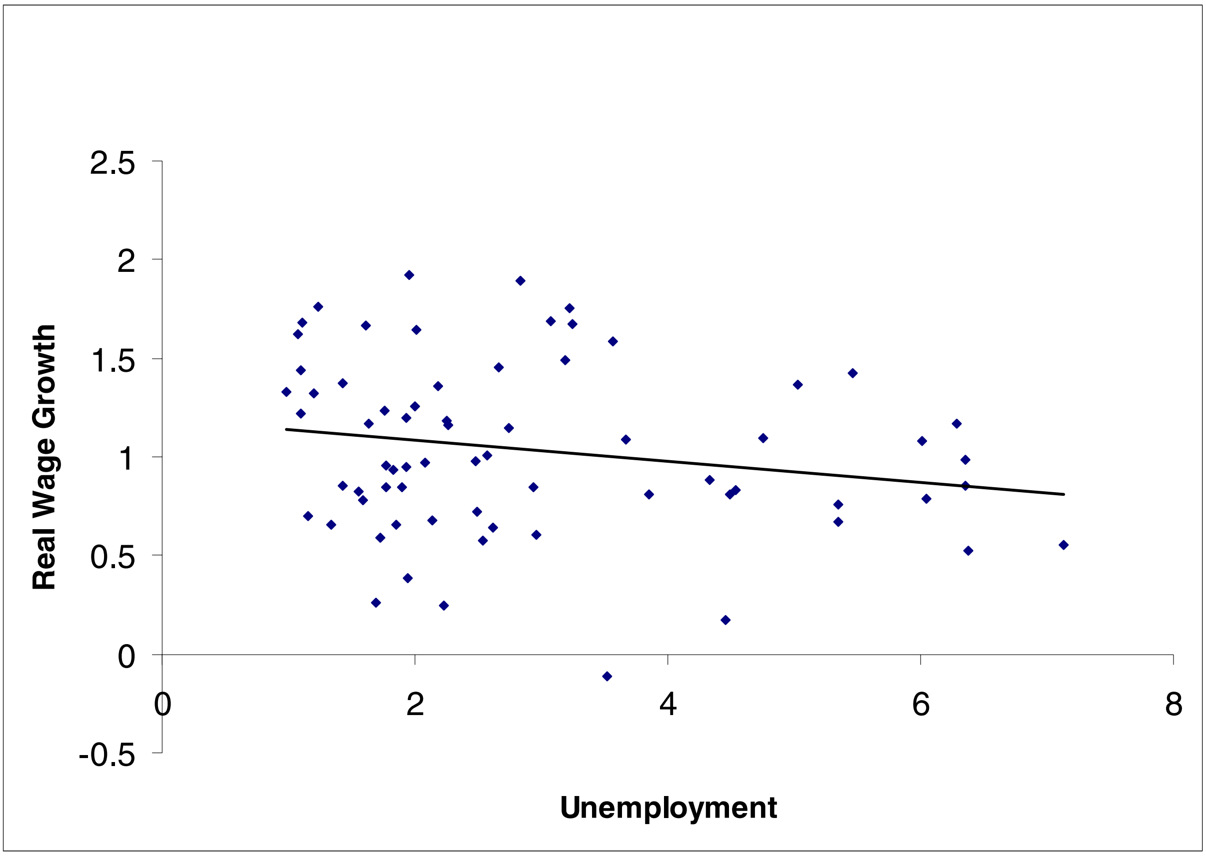


Figure 5. Labor Productivity and Business Cycle Fluctuations

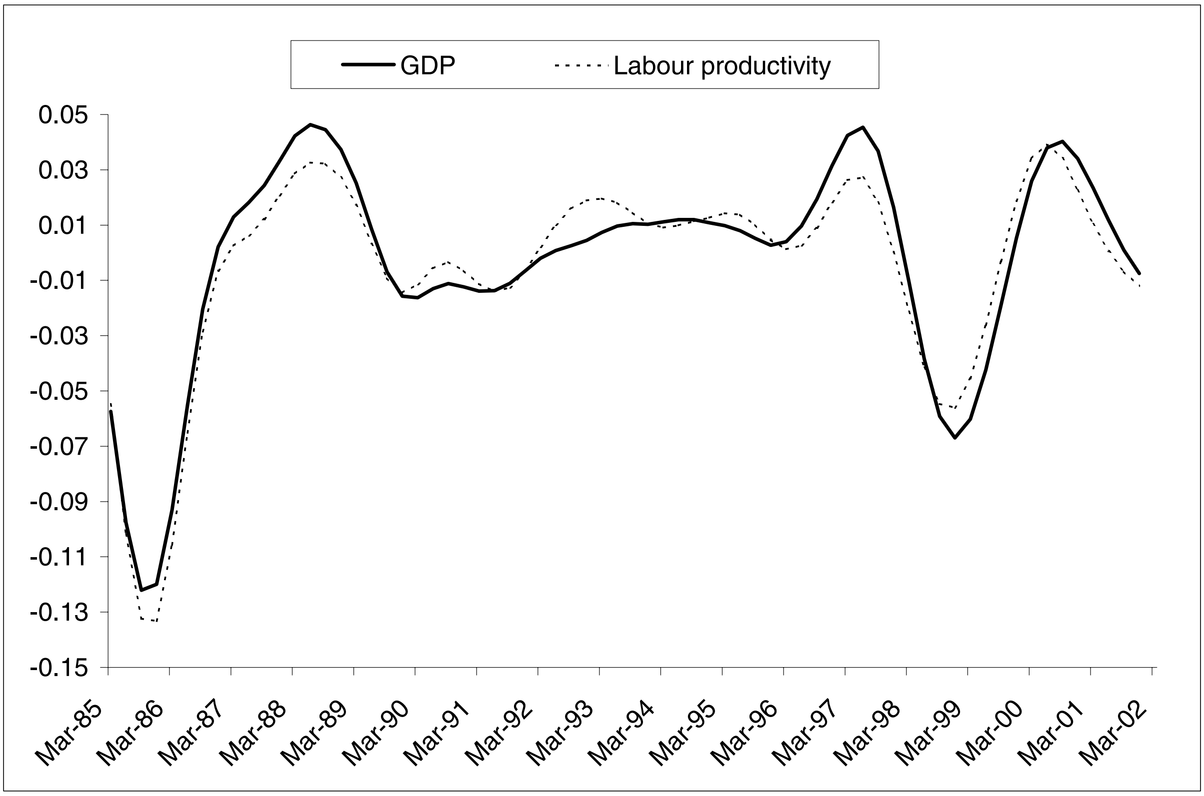


Figure 6. Business Cycle Fluctuations of Employment and GDP

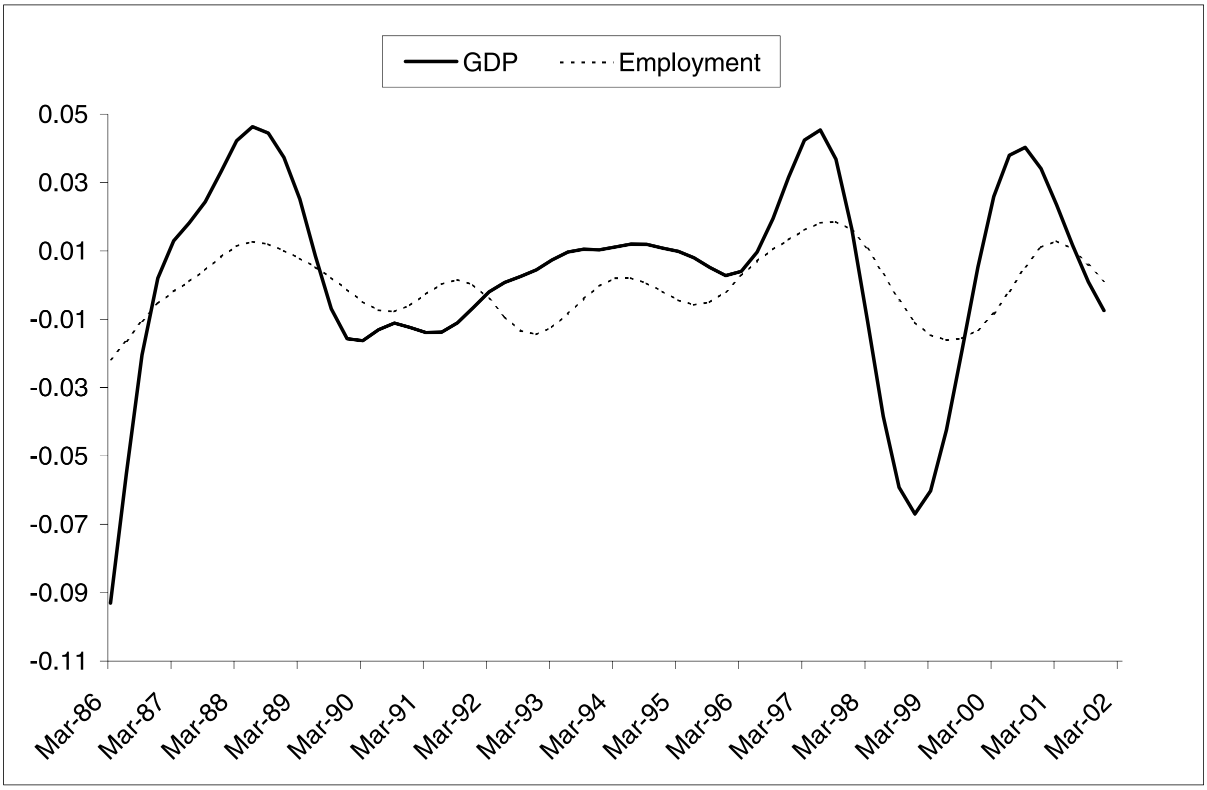


Figure 7a. Real Wages and Labour Productivity

Figure 7b. Real Wages and Labour Productivity

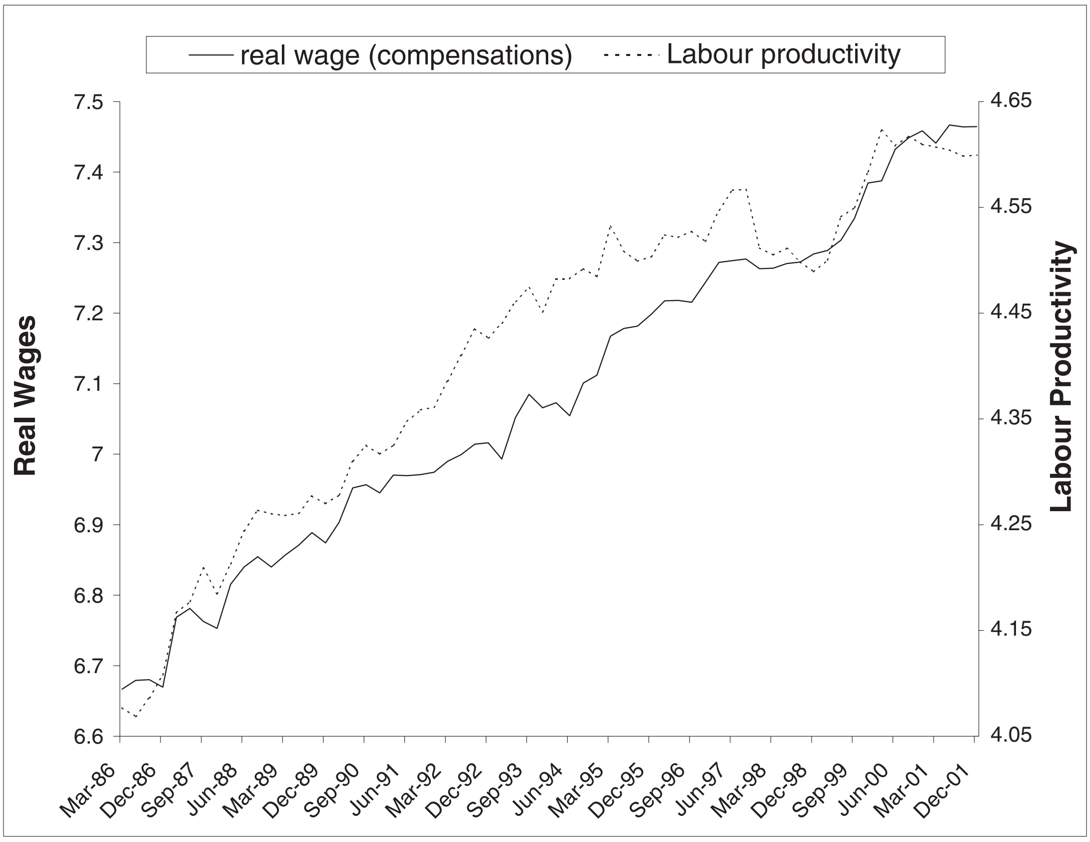


Figure 7c. Real Wages and Labour Productivity

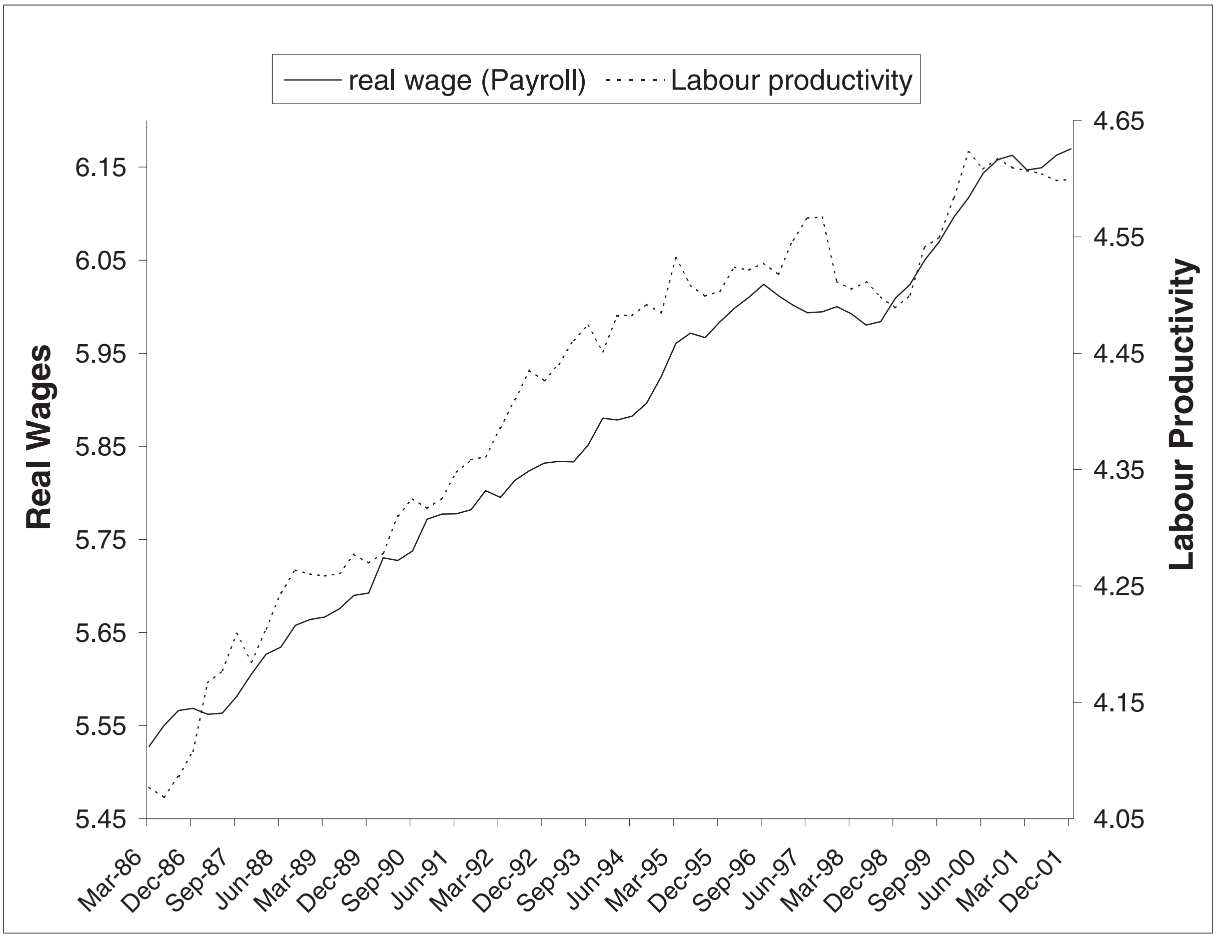


Figure 8a. CPI Inflation & Log Markup

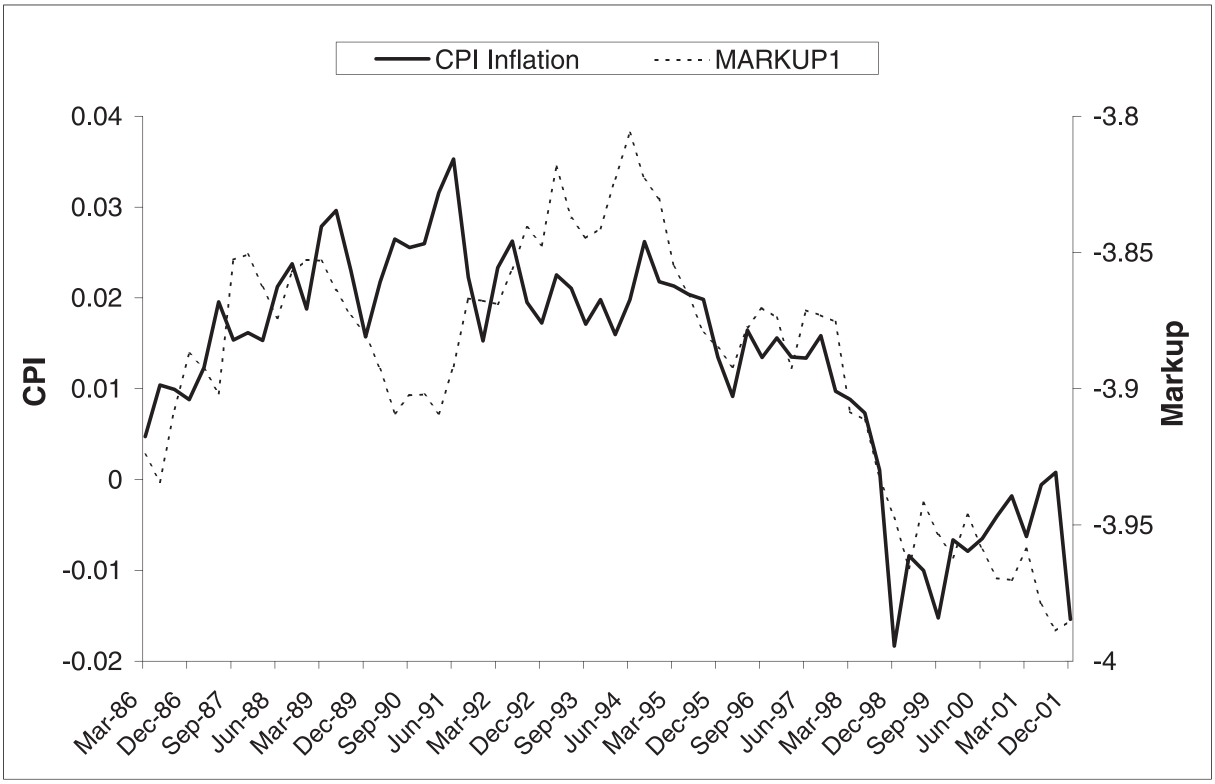


Figure 8b. CPI Inflation & Log Markup

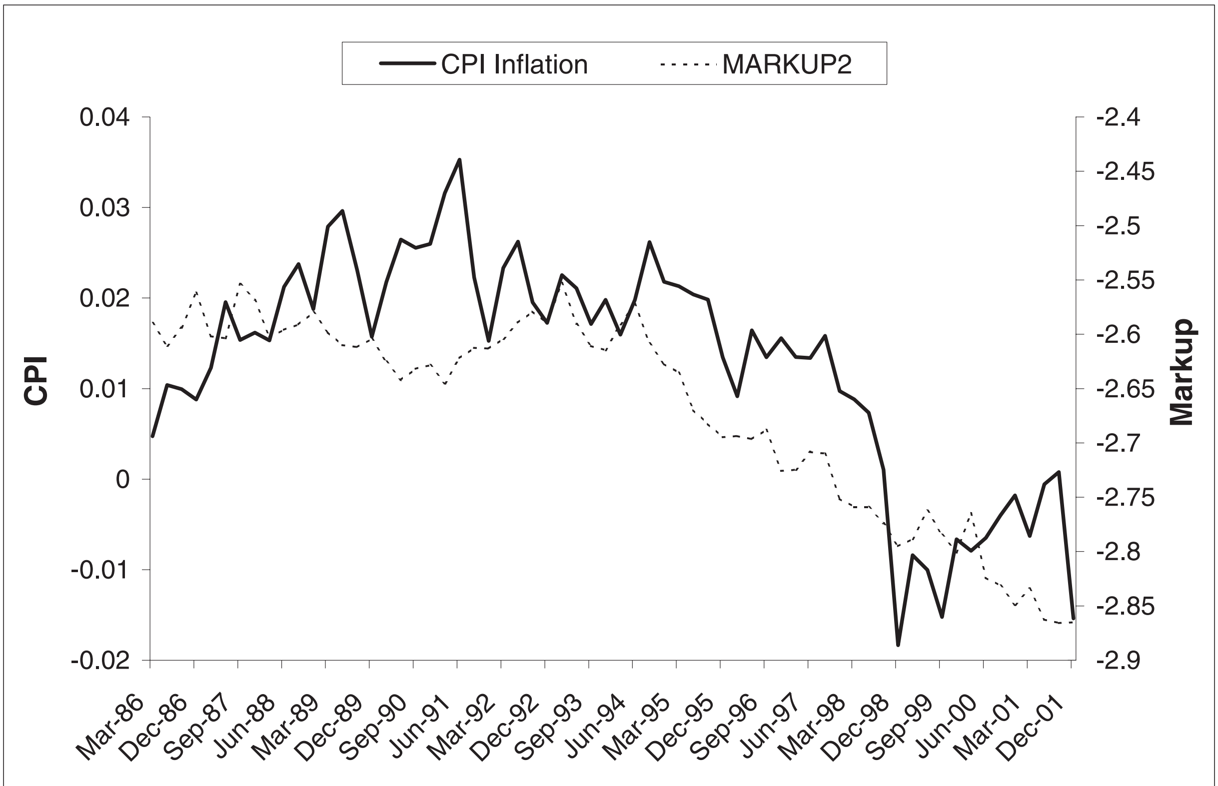


Figure 8c. CPI Inflation & Log Markup

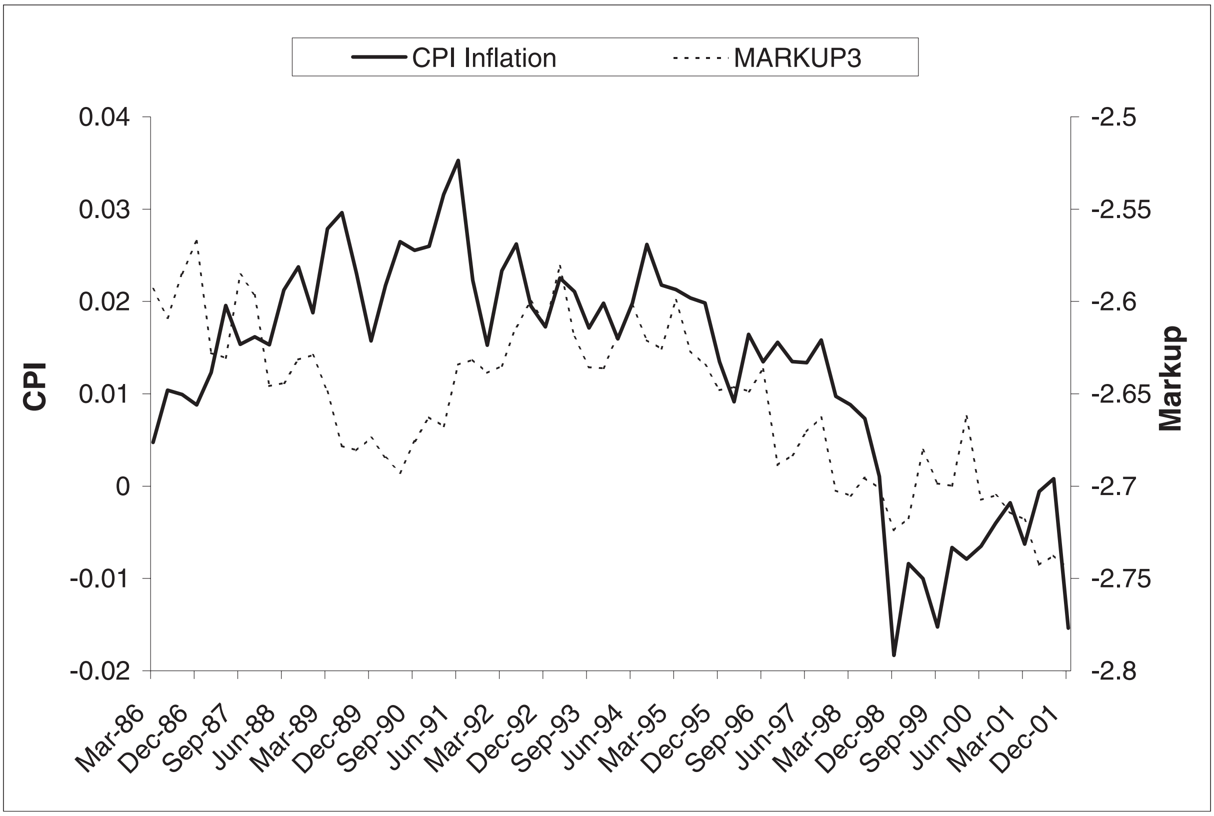


Figure 8d. CPI Inflation & Log Markup

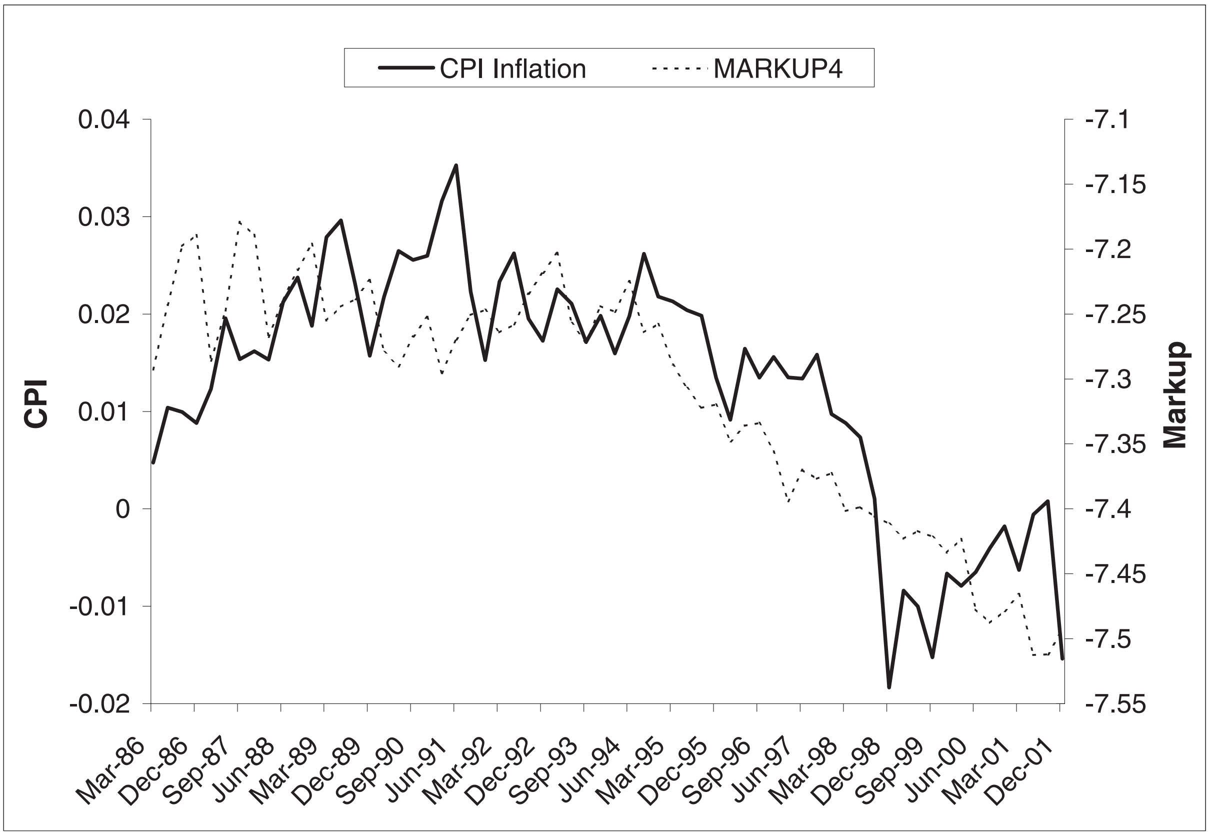


Figure 9a. Out-of-Sample-Forecasts of the Traditional Phillips Curve

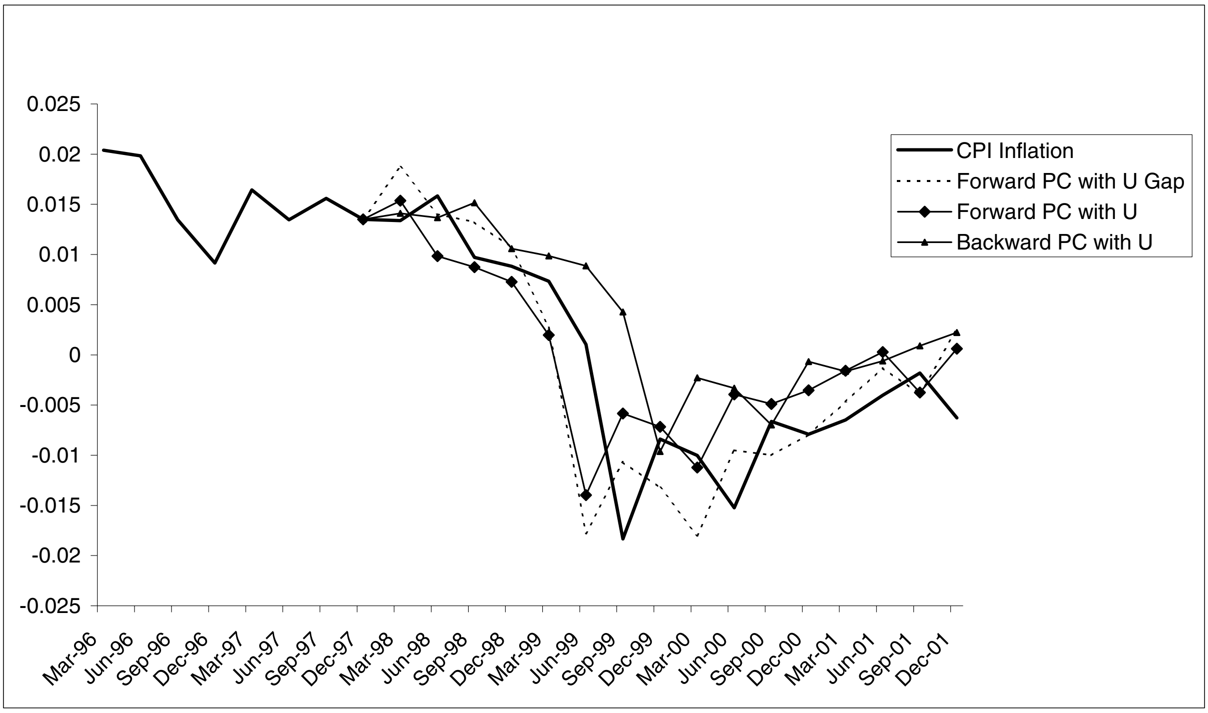


Figure 9b. Out-of-Sample-Forecasts of the Traditional Phillips Curve

Figure 9c. Simulation of the Mark-up Model 1998-2001

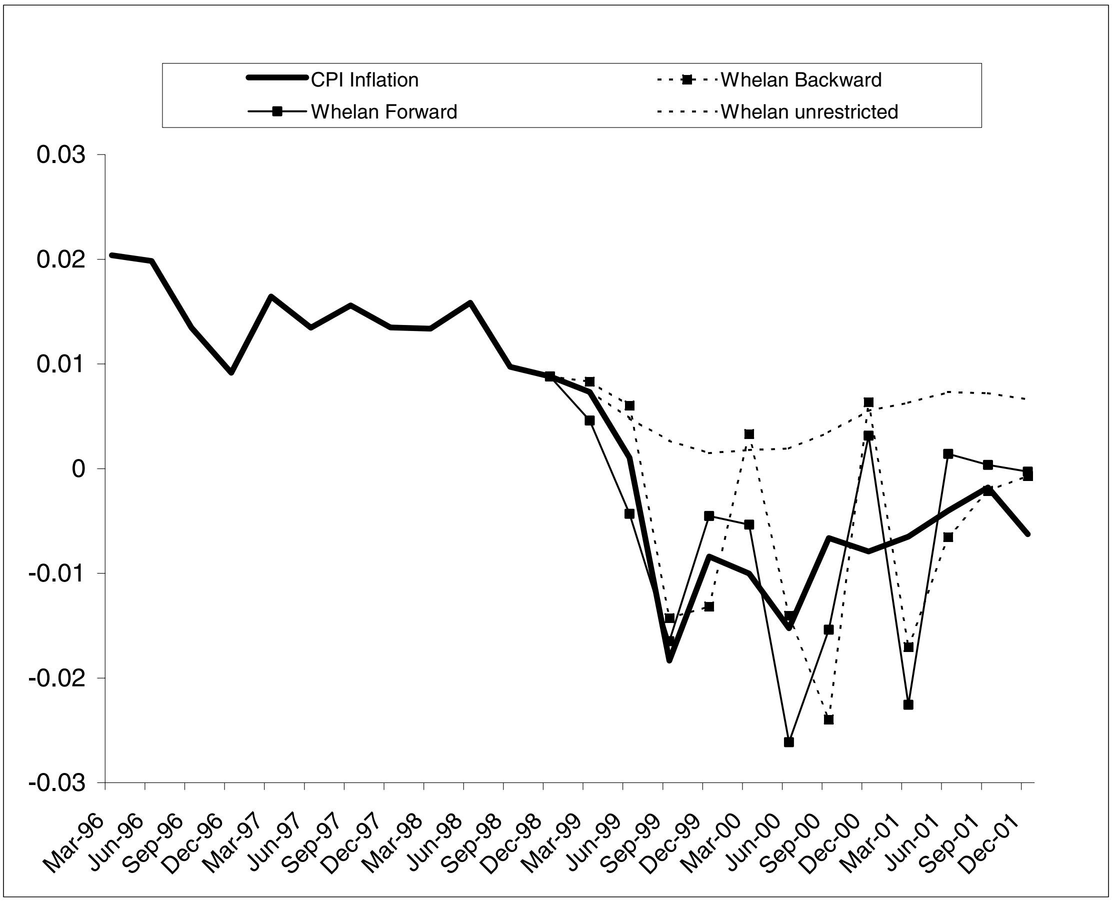
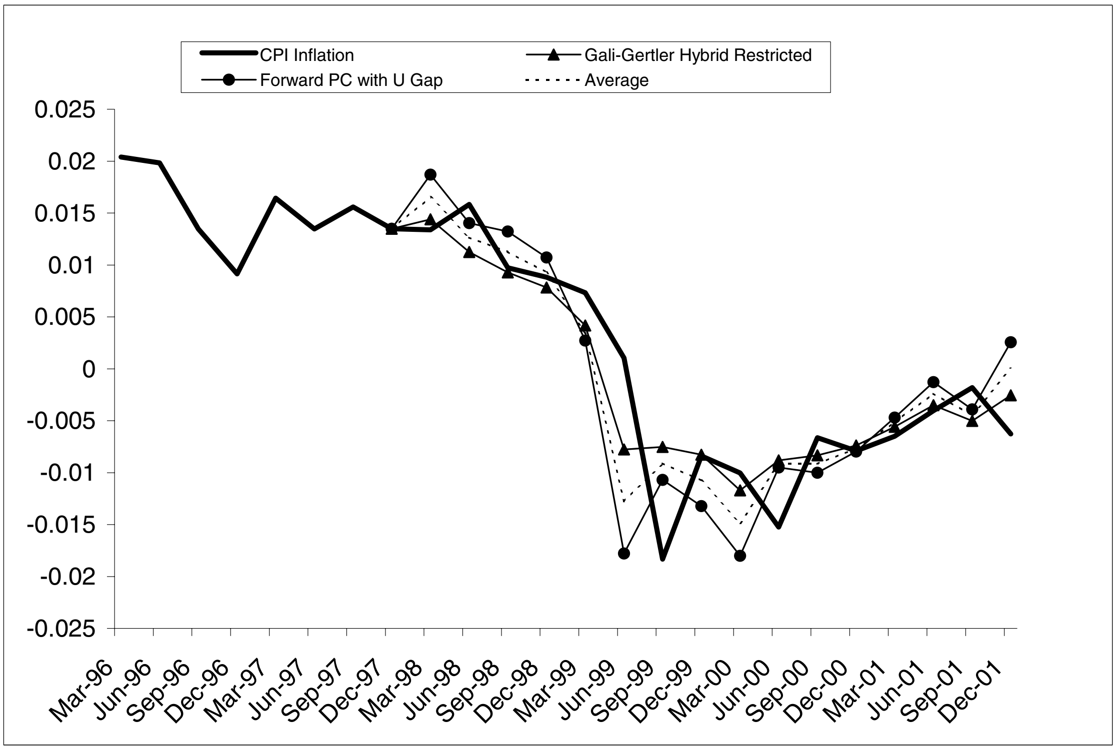


Figure 9d. Average Out-of-Sample Forecasts of Best Models



Appendix 1. Data

The source of the data is the Hong Kong Monetary Authority. The data were seasonally unadjusted. The data are quarterly, and the sample span varies from one variable to another. The notations of the levels are as follows:

P : The CPI price level,
def : The GDP deflator,
W : The nominal payroll wage,
$\overline{W}$: Total compensations to employee,
Y : Real production GDP,
PH : Private property price,
PO : Office space price,
PR : Retail space price,
PF : Factory space price,
P^A : Average of all the four property prices,
U : The unemployment rate,
E : Employed persons,
P^C : China's CPI,
P^U : US CPI[a]

The data are seasonally adjusted by fitting several different models to the raw data. These are additive and multiplicative seasonally without trend, linear trend and exponential trend. The model with the smallest Schwartz Information Criteria is then chosen. The models are summarized below.

Variable	Trend	Seasonal
P	Linear	Multiplicative
def	Linear	Multiplicative
W	None	Multiplicative
$\overline{W}$	Linear	Multiplicative
Y	Exponential	Multiplicative
PH	None	Multiplicative
PO	None	Multiplicative
PR	None	Multiplicative
PF	None	None
U	Linear	Multiplicative
E	Linear	Multiplicative
P^C	Linear	None
P^U	Already seasonally adjusted	

a: Source is the Federal Reserve Bank of St. Louis. Lowercase means logs. Quarterly growth rates are defined as $\ln X_t - \ln X_{t-1}$.

Appendix 2. Unit Root Tests

	ADF		ADF		Phillips-Perron		Rothemberg-Elliott-Stock		Rothemberg-Elliott-Stock	
	t	Lags (Akaike)	t	Lags (Schwartz)	t	Bandwidth	t	Lags (Akaike)	t	Lags (Schwartz)
p_t	-1.36	3	-0.26	1	1.68	5	-2.76	3	-2.76	3
Δp_t	-1.48	10	-2.37	0	-2.12	2	-1.15	10	-1.93	0
$\Delta^2 p_t$	-3.31*	9	-8.94**	1	-10.3**	7	-2.85*	9	-8.66**	1
Δp_t^C	-3.11	4	-4.08**	0	-4.08**	0	-3.27**	4	-3.78**	0
Δp_t^U	-2.70	2	-4.86**	0	-4.89**	3	-2.81*	2	-4.91**	0
p_t^A	-0.23	5	0.03	0	-0.27	4	-0.73	2	-0.73	2
u_t	-3.82**	10	-4.03**	7	-3.23*	3	-1.34	7	-2.08	0
w_t	3.51	0	3.51	0	2.50	4	-2.15	6	-0.83	3
$\overline{w}_t$	0.69	2	0.37	0	1.89	23	-0.82	5	-0.82	5
y_t	-2.38	5	-2.34	0	-2.29	2	-1.20	5	-1.44	0
ulc_t	-1.93	0	-1.93	0	-1.93	1	-1.37	0	-1.37	0
m_t	-1.93	0	-1.93	0	-1.93	1	-1.37	0	-1.37	0
m'_t	-2.07	0	-2.07	0	-1.96	1	-1.87	0	-1.87	0
m''_t	-2.87	0	-2.87	0	-2.82	1	-2.89*	0	-2.89*	0
m'''_t	-2.83	0	-2.83	0	-2.83	0	-2.27	0	-2.27	0
q_t	-2.18	0	-2.18	0	-1.98	9	-1.41	0	-1.41	0

- ADF Model: $\Delta \ln x_t = \alpha + \beta T + \rho \ln x_{t-1} + \sum_{i=1}^{K} \delta_{t-i} \Delta \ln x_{t-i} + \varepsilon_t$. The Phillips-Perron model is the same as the ADF, the residuals are used to compute $\hat{\gamma}_0 = (T-2)^{-1} \sum \hat{\varepsilon}_t^2$ and the variance $\hat{\lambda}^2$ is estimated using the Newey-West method assuming that the truncation lag goes to infinity as the sample size grows.
- The Rothemberg-Elliott-Stock (1996) DF-GLS test also includes trend.
- ulc_t is the share of labour measured as total compensations to employee / nominal GDP.
- m_t is the mark-up measured as the inverse of the labour share, m'_t is measured as the inverse of log (compensations . total employment) / (CPI . real GDP), m''_t is the inverse of log (compensations total employment) / (GDP deflator . real GDP), and m'''_t is the inverse of log (compensations . total employment) / (nominal GDP - indirect taxes).
- p_t^A is the average of all four property prices and q_t is labour productivity measured as log (real GDP / employment).
- Asterisk means significant at the 10 per cent level, and double asterisks mean significant at the 5 per cent level.