HONG KONG INSTITUTE FOR MONETARY RESEARCH

INFLATION IN HONG KONG, SAR - IN SEARCH OF A TRANSMISSION MECHANISM

Hans Genberg and Laurent Pauwels

HKIMR Working Paper No.1/2003

January 2003

Inflation in Hong Kong, SAR - In Search of a Transmission Mechanism

Hans Genberg
Graduate Institute of International Studies
Hong Kong Institute for Monetary Research

and

Laurent Pauwels
Graduate Institute of International Studies

January 2003

Abstract

Inflation in a country with a currency board is usually believed to be highly dependent on external factors. Important questions for understanding the dynamics of inflation are (i) how best to measure these factors and (ii) how to model the transmission mechanism. This paper brings evidence to both questions. First, the paper shows that using CPI-based measures of foreign inflation does not adequately capture external influences on inflation in Hong Kong. Second, the paper shows that import prices and wages have a significant causal role. Together these conclusions suggest that Hong Kong's price dynamics can be modeled by a Phillips Curve in which marginal cost of production plays an important role. When we estimate a New Phillips curve model for Hong Kong, a significant forward-looking component to expectations is identified. In addition, we find that prices are relatively flexible in HK, with adjustments taking place almost twice as fast as in the United States. Finally import prices and property rental rates appear to be important components of marginal cost of production alongside wages. More traditional versions of the Phillips curve also fit the data quite well. Even in this traditional specification, however, measures based on changes in production cost outperform measures of excess demand as forcing variables.

Comments from Stefan Gerlach, Jimmy Ha, and Wensheng Peng of the HKMA and Andrew Rose and other participants in a HKIMR seminar are gratefully acknowledged without implication.

1. Introduction

The focus of this study is the determinants of inflation in Hong Kong since the establishment of the currency board arrangement in October 1983. While it is uncontroversial to assert that foreign factors ultimately determine domestic inflation in a rigidly fixed exchange rate system, the exact nature and speed of the transmission mechanism is less well understood. It is well documented that deviations from purchasing power parity (PPP) can persist for long periods of time, leaving open the possibility that local factors can play a role for domestic price developments in the meantime. For example, lessons from the Bretton Woods system and the European Monetary System showed that the anchors provided by (admittedly adjustable) fixed exchange rates were not as rigid as might have been expected. More recently, some observers have argued that the fixed exchange rate of the Argentine Peso vis-à-vis the U.S. dollar was in part to blame for the breakdown of the currency board arrangement in that country. According to this argument, the general appreciation of the dollar in the late nineties led to an overvaluation of the Peso on a trade-weighted basis, because domestic inflation did not come down sufficiently to offset the nominal effective appreciation. In other words, domestic inflation was not completely determined by external price developments.

In a floating exchange rate environment, the so-called pass-through of exchange rate changes to domestic prices has proven to be less than one for one, sometimes substantially less so. Since fixing one's exchange rate to one particular currency implies floating relative to many others that are important trading partners, incomplete pass-through implies a less than perfect relationship between domestic and foreign prices even in a currency board.

This paper aims to increase our understanding of the inflation process in Hong Kong by studying the transmission mechanism of foreign price and exchange rate developments to domestic inflation. It also seeks to identify a relationship between changes in costs of production and price developments along the lines of the literature on the so-called New Phillips curve. Two recent studies have already provided some evidence on these issues. Cheung and Yuen (2001) show that that consumer price indices (CPI) in Hong Kong and the United States are cointegrated in a sample that extends from 1984 to 1997. When they estimate the implied two-variable vector-error-correction (VEC) model, they find that shocks to the U.S. CPI have a strong influence on the HK CPI with a lag of some two years.

As part of constructing a small macroeconometric model of the Hong Kong economy, Ha, Leung and Shu (2002) estimate what amounts to an error correction model for the rate of change in the CPI with the output gap and property price inflation as additional regressors.[1] The error correction term measures the difference between the domestic inflation and a weighted average of the inflation rates in the U.S. and Mainland China. The estimate of the weight for the U.S. turns out to be 92%. Lagged values of import price inflation, property price inflation and the output gap all have significant explanatory power.

---

1 The sample in their study extends from 1990Q1 to 2001Q4.

While it is reasonable that the United States should exert a strong influence on the Hong Kong economy in view of both the importance of the U.S. in the world economy and the close relationship between HKD and USD interest rates, it is less obvious that the price developments in the United States should be dominant. To the extent that imports and exports of goods and services are the principal reasons for the transmission of inflation, the size of the bilateral trade with the U.S. should give an indication of its importance for Hong Kong. As Table 1 shows, although the U.S. does figure dominantly as a destination for HK exports, its share in HK imports is modest. Furthermore, its importance has been diminishing over time. On the other hand, the share of Asian countries has increased, especially as a destination for exports.

In view of the moderate size of direct trade with the United States, this paper first shows that a more comprehensive measure of foreign price developments must be considered to describe adequately the direct external price pressures on Hong Kong (Section 2). It then sets out a theoretical framework based on an open-economy version of a New Keynesian Phillips curve (Section 3) that servers as a basis for both structural and non-structural econometric work in Section 4. A summary of the main findings and a discussion of the need for further research concludes (Section 5).

2. A first look at the data

To fix ideas we start by presenting some simple plots of the variables that we are dealing with. Figure 1 shows the evolution of two measures of the price level in Hong Kong, the CPI and the GDP deflator, since 1984.[2] Three phases of price developments can be identified. During the first period that lasts from 1984 until 1989 for the deflator (about two years later for the CPI) inflation rates are gradually increasing. Thereafter inflation rates regularly decline again until we reach complete price level stability in late 1997 (first half of 1998 for the CPI). Finally in the third phase there is actually price deflation until well into 2001. As we shall see, the main challenge for any empirical model is going to be to account for the deflation since 1997.

The reason both for the apparent success of the U.S. inflation rate to account for HK price developments and for our claims that this may be spurious, is visible in Figure 2 that depicts both the HK GDP deflator and the U.S. CPI. There is indeed a gradual increase in inflation in the U.S. until late 1990 followed by a modest slow-down until 1997.[3] This pattern may be the reason for the cointegration and VEC results reported by Cheung and Yuen (2001) whose sample ends in 1997. But this is exactly where the problem starts for an explanation relying heavily on imported inflation from the U.S., because while deflation sets in at about that time in Hong Kong, there is no visible change in the U.S. inflation rate.

2 See the appendix for a description of the data sources.

3 The variation is much smaller than for Hong Kong, but the underlying data confirm the statement.

While the events associated with the Asian Financial Crisis and the greater integration with Mainland China surely are important explanations for the post 1997 deflation, we believe that this is only part of the story. One reason is illustrated in Figure 3, which presents an index of import prices and a measure of world prices relevant for Hong Kong. Both are of course measured in HKD units. What particularly distinguishes these indices from the U.S. CPI is the deflationary trend they exhibit since the middle of 1995. This suggests the hypothesis that the deflation in Hong Kong since 1997 was at least in part due to development of prices in main trading partners one or two years earlier.

We conclude this preliminary look at the data by showing the evolution of bilateral exchange rates of the HKD with respect to three major trading partners and one measure of the effective exchange rate. It is clear from this figure that the HKD has seen substantial movements with respect to both China and Japan, and less extreme, but nevertheless significant, movements on an effective basis. It would be surprising if the sharp movements in the Yen exchange rate, for example, did not have some impact on HK prices given the relatively large amount of trade between the two regions. More generally, movements in the effective exchange rate and the price levels in the corresponding foreign countries need to be considered.

3. A theoretical perspective: Phillips curves, Old and New

Our preliminary preview of the data suggests that import prices play a potentially important part in the inflation process. This is the case not only for inflation measured by the CPI, in which case it could be due to a direct pass-through effect on imported consumer goods, but also for the GDP deflator which by definition excludes such a direct effect. This is suggestive of a transmission mechanism where imported goods are used as inputs together with labor and potentially other factors of production in the production of domestic goods. In this section we will describe a Phillips curve based on the work of Gali and Gertler (1999) that incorporates this idea.

In models based on the traditional Phillips curve inflation was written as a function of some measure of excess demand in the economy. In the so-called expectations-augmented version, a term was added to capture past expectations of the current inflation rate as in (1):

$$\pi_t = c_1 + c_2 s_t + c_3 E_{t-1}\,\pi_t \tag{1}$$

where π represents inflation, s a measure of excess demand, and E_{t-1} represents expectations based on information at time t-1. In most empirical applications the expectations term was written as a linear combination of past inflation rates and excess demand was usually measured by the unemployment rate (u) or the deviation of actual output from its natural level $(y\text{-}y^n)$.

$$\pi_t = c_1 + c_2 u_t + c_3 \sum_{i=1}^{n} \lambda_i \pi_{t-i} \tag{2a}$$

$$\pi_t = c_1 + c_2 (y_t - y_t^n) + c_3 \sum_{i=1}^{n} \lambda_i \pi_{t-i} \tag{2b}$$

Since it was originally conceived of as a purely empirical relationship, this version of the Phillips curve does not have a strong theoretical basis, making it difficult to associate estimated coefficient with behavioral parameters. The "New Phillips curve" seeks to remedy this shortcoming by explicit modeling of price setting by firms. Much of the current literature is based on the work of Taylor (1980) and Calvo (1983). The framework of Calvo is a monopolistically competitive producer who sets prices infrequently and holds them fixed for several periods. The assumption of monopolistic competition leads to a mark-up of prices over marginal cost, and the infrequent adjustment of prices implies that not only current marginal cost will be relevant, but also expected future marginal cost. By making simplifying assumptions about the process of price adjustments, it is possible to derive an equation that has the form of the old Phillips curve, but where expectations are forward looking, and where the term measuring excess demand has been replaced by a term incorporating real marginal cost, rmc, as in (3).[4]

$$\pi_t = c_1 + c_2 rmc_t + c_3 E_{t+1}\, \pi_t \tag{3}$$

The coefficients c_2 and c_3 can be related to underlying structural parameters. Specifically if we follow Calvo and let θ denote the probability that a firm keeps its prices fixed during any given period, then it can be shown that

$$c_2 = (1-\theta)(1-\beta\theta)/\theta$$
$$c_3 = \beta$$

where β represents the discount factor.

Gali and Gertler (1999) estimate a specific form of (3) by considering a model where labor is the only variable input. Assuming further that the marginal cost of labor is proportional to the average cost, their measure of real marginal cost is equal to the labor share.

Fuhrer and Moore (1995) and Fuhrer (1997) criticized the purely forward-looking form of expectations of inflation in (3). They showed that the empirical performance of the model improved if lags of inflation were also included. Equation (4) below captures this notion, which has been justified theoretically by assuming that a fraction of firms set prices according to the forward-looking hypothesis, while the remainder use a rule of thumb based on past inflation performance.

$$\pi_t = c_1 + c_2 rmc_t + c_3 E_t \pi_{t+1} + c_4 \pi_{t-1} \tag{4}$$

Assume, following Gali and Gertler (1999), that a fraction $1-\omega$ of firms are forward looking and set prices according to the Calvo model referred to above. The remaining firms follow a backward-looking rule-of-thumb rule for their price adjustment. As before, for all firms the probability of adjusting the price in any given period is $1-\theta$. With these assumptions, Gali and Gertler show that

[4] Under certain conditions excess demand is proportional to marginal cost in which case the old and the new Phillips curves will differ from each other only by the form of the expectations term.

$$c_2 = (1-\omega)(1-\theta)(1-\beta\theta) / \{\theta + \omega [1-\theta (1-\beta)]\}$$

$$c_3 = \beta\theta / \{\theta + \omega [1-\theta (1-\beta)]\}$$

$$c_4 = \omega / \{\theta + \omega [1-\theta (1-\beta)]\}$$

In an open economy where imported intermediate goods are important in the production of final goods, import prices become a significant source of changes in marginal cost. In such a situation, Devereux and Yetman (2002) derive an inflation equation where the real marginal cost variable is measured by the real exchange rate (measured using import prices) relative to its equilibrium value.

In the Hong Kong context we hypothesize that not only wages and import prices of intermediate goods are variable in the short run, but also that rental of factory, office and retail space is a significant component of marginal cost. In the empirical work we will therefore consider a marginal cost measure that encompasses all three variables.

4. Empirical implementation

4.1 Preliminaries: unit roots, cointegration and 'causality'

We start by using more formal statistical methods to describe the time series properties of the data series that are likely to be important for the issue of the transmission mechanism. As usual we start by considering unit-root properties summarized in Table 2. Not surprisingly all the series presented there appear to contain at least one unit root. More surprisingly is the failure to reject the presence of two unit roots for both HK price indices (GDP deflator and CPI), and the U.S. CPI, as well as for the nominal wage rate index in Hong Kong. Taken literally, this would imply that the inflation rates and the rate of change in wages could wander to very large positive or negative values without tendency to revert to some mean. This is hard to believe as a general proposition as opposed to a sample-specific feature. In view of the notoriously low power of the unit root tests against the alternative hypothesis of stationarity, we shall in the following consider both the order of integration indicated in the table, and the possibility that all variables are integrated of order one.[5]

Next we investigate interrelationships in the data based on bivariate time-series properties. We consider three complementary measures; tests for cointegration, tests for Granger-causality, and impulse response functions and variance decompositions from bivariate vector autoregressions (VARs) or vector error correction models (VECs) where appropriate.

[5] One possible reason for the apparent I(2) feature of some of the data series is the presence of a structural break. Pauwels (2002) investigates this possibility in detail and he cannot reject the null hypothesis of one time change in the mean in 1997 Q2 of the $PGDP^{HK}$ and W^{HK}, all in log and first difference. No empirical evidence of such break is found for CPI^{HK}, for which one might consider the low power of the unit root against the alternative. For the purpose of the regressions in this paper, we took the first differences of the unit root variables. It is, however, difficult to remove the problem caused by the structural break as there are few observations between the break and the end of the sample.

Table 3a summarizes the results obtained when general Hong Kong price indices are related directly to foreign CPIs. The first four rows concern the relationship between Hong Kong and the U.S. The main point to notice here is that there is no evidence of cointegration between pairs of these variables either in levels or first-differences when the data spans the whole period until the end of 2001. Furthermore, for the full sample there is no evidence of any significant bivariate relationship between the HK and the U.S. CPIs using either Granger causality tests or VAR-based indicators. This contrasts with results obtained from a sample that ends in the first quarter of 1997, where there is some, albeit not strong, evidence of both cointegration and influences of U.S. inflation on HK inflation. In view of the lack of any such relationship in the full sample, however, one might surmise that the results for the shorter sample are more of a coincidence than a structural phenomenon.

The next two rows in the table look at the relationship between HK prices and an index of CPIs for the fourteen most important trading partners. In this case, we do find evidence of cointegration as well as significant Granger causality and VAR relationships. But even here there are some puzzles. When we use the GDP deflator as the domestic price index, both the causality test and the VAR statistics indicate a dependence of the rest of the world on Hong Kong! Clearly this cannot be the case in any structural sense, so this result must be viewed with suspicion. Perhaps the bivariate relationship between the variables is due to the common influence of some third variable but with different time profile.

Taken together, these results suggest that no single individual country's CPI can be used to represent adequately the external influences on inflation in Hong Kong. At the very least, the combined effects of all trading partners must be considered. But the results also show that a direct pass-through of external prices to domestic prices may not be the best characterization of the transmission mechanism. Indeed, we shall argue that this mechanism is considerably more complicated and indirect.

As a further step towards identifying a transmission mechanism for HK inflation we look at relationships between a set of purely Hong Kong variables in Table 3b. The first four lines involve the two general price indices on the one hand and indices of import prices and nominal wages on the other. The essential message that emerges here is that both import prices and nominal wage have significant influence on the more general price indices. While there is some evidence of bi-directional Granger causality when the CPI is involved, if one judges from the VAR measures, the main direction of influence appears to be from wages to prices.

The next row indicates that wages and import prices are not cointegrated, but do show mutual dependence on each other in the Granger causality tests.

The table finally presents results involving an index of local property prices.[6] Recall that the inflation regression in Ha, Leung and Shu (2002) did include property prices as a significant explanatory variable. The bivariate time-series relationships presented here are consistent with those results, but they also suggest the possibility of reversed causality, particularly with respect to the GDP deflator. With respect to nominal wages and import prices, the main message seems to be a relationship from import prices to property prices.

What general conclusions can be drawn from these results? We believe that two points should be emphasized because of their importance for the modelling of the inflation process. The first is that the direct link between HK inflation and foreign CPI inflation, even if it is measured by an average of trading partners' inflation rates, does not capture adequately the transmission mechanism. The second is that development of import prices and wages do seem to have a significant causal role. Together these conclusions suggest a hypothesis along the line of the New Phillips curve extended to an open economy where imports, in addition to labor, are used as inputs in local production. We explore this possibility in the next section.

4.2 An empirical implementation based on cointegration

If inflation is a stationary variable, and if expected inflation therefore is stationary, equations (3) and (4) imply that real marginal cost must be stationary. Since real marginal cost (measured in logs) is the difference between nominal marginal cost and the price level (also measured in logs), it follows that the price level and nominal marginal cost must be cointegrated. Our first empirical implementation of the theoretical arguments therefore involves testing for cointegration between either the GDP deflator or the CPI as a measure of the general price level and a vector of three variables consisting of import prices, the nominal wage rate and property prices as a measure of nominal marginal cost.

The results presented in Table 4a for the GDP deflator and Table 4b for the CPI are consistent with the hypothesis that the general price level and the hypothesized components of marginal cost are cointegrated.[7] Furthermore, in none of the cases is it possible to reject the hypothesis that the sum of the coefficients on these components is equal to one.

Cointegration implies that the variables can be related to each other by a vector error correction (VEC) model. The last column in the tables reports the so-called adjustment coefficient in the VEC model. This coefficient measures how the error-correction term impacts the change in the dependent variable. Our hypothesis is that the error-correction term can be interpreted as the real marginal cost variable relevant for inflation. The results show that for all specifications in the table, the price level is strongly affected by the error correction term.

---

6 As an alternative to property prices we considered using an index of rental rates. However, the data available on rental rates are not sufficiently long and complete to make this practical. To the extent that rental rates are proportional to property prices, the latter will be a good proxy for the rental component of marginal production cost.

7 The table reports results using three different lag lengths of the first differences of the endogenous variables. The results are not materially different between these specifications.

Figure 5 shows the result of dynamic simulations of the VEC assuming that import prices are exogenous (the solid bold line) and that all three components of the marginal cost vector are exogenous together (the dashed bold line).[8] While the model does explain the evolution of the GDP deflator very well if the marginal cost vector as a whole is taken to be exogenous, it is apparent that it can not account for this evolution if the wage rate and property prices are endogenous.[9] Evidently a more complete model is required to account for the price-wage-property price nexus.

In section 2 we argued that the main challenge for any model of inflation in Hong Kong is to explain the declining price level since mid-late 1997. Figure 5 already showed that as long as we use the realized values of import prices, wages, and property prices the VEC model can account for this evolution. Figure 6 adds some complementary information to this assessment. It represents dynamic simulations starting in the first quarter of 1995. When the marginal cost variables are exogenous, the model is as expected able to explain the declining price level beyond 1998, although the turning point seems to be about half a year later than the actual. This figure also shows that the evolution of import prices alone cannot account for the deflation. It can explain a leveling off of the GDP deflator, but the VEC does not capture the dynamics of wages and property prices well enough to be able to generate a falling price level.

4.3 Fitting a New Phillips curve for Hong Kong

Recall that 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 current expectations of future inflation. Assuming further that not all firms are forward looking we obtain a hybrid version where past inflation also plays a role. For convenience we reproduce the corresponding equation here together with the equations defining the relationships between the coefficients and the underlying structural parameters.

$$\begin{aligned} \pi_t &= c_1 + c_2 rmc_t + c_3 E_t \pi_{t+1} + c_4 \pi_{t-1} \\ c_2 &= (1-\omega)(1-\theta)(1-\beta\theta)/\{\theta + \omega\,[1-\theta\,(1-\beta)]\} \\ c_3 &= \beta\theta/\{\theta + \omega\,[1-\theta\,(1-\beta)]\} \\ c_4 &= \omega\,/\{\theta + \omega\,[1-\theta\,(1-\beta)]\} \end{aligned} \qquad (4)$$

To estimate the parameters in this equation we assume, following the results in the previous section, that real marginal cost can be measured as a linear combination of the cost of intermediate imports, labor, and office/factory space. We assume further that the appropriate linear combination is given by the estimated cointegration relationship between the GDP deflator (CPI) and these cost variables.

[8] The dependent variable in this figure is the GDP deflator. The corresponding figure with the CPI as the dependent variable is very similar.

[9] A detailed inspection of the results shows that it is the wage rate in particular that is not well explained by the VEC.

We start by estimating a restricted version of (4) where we assume that $c_4 = 1 - c_3$. For plausible values of the discount rate β, this is almost exactly true.[10] Using the point estimates of c_3 and c_4 we calculate the implied values of θ and ω. To account for the endogeneity of the expectations of future inflation we estimate the parameters using the Generalized Methods of Moments (GMM).

Results based on the GDP deflator are presented in Table 5a. Although the point estimates differ somewhat depending on the number of lags of the instruments, they are all of the same order of magnitude. Furthermore, the implied values of the parameters ω and θ are relatively close across specifications. If the underlying model is correct, these values suggest that somewhere between 46 and 63 per cent of firms are forward looking, and that prices remain fixed for between 2.2 and 2.9 quarters on average. This can be compared to the preferred estimates in Gali-Gertler (1999), which imply that prices remain fixed for about 5 quarters in the United States. The greater flexibility of prices in Hong Kong implied by our estimates is consistent with conventional wisdom.

Table 5b contains estimates for equations where CPI inflation is the dependent variable. In this case the coefficient estimates are extremely sensitive to the number of lags admitted for the instruments. In two cases the point estimates of c_2 and c_3 imply values of θ and ω that are not in the permissible range between zero and one. We conclude provisionally that the model therefore is inapplicable for this case.

Next we estimate the parameters θ and ω directly by substituting the expressions for c_2, c_3, and c_4 into equation (4) and applying non-linear GMM estimation.[11] The results are reported in Table 6. To reach convergence we had to assume a value for the discount factor β.[12] As noted above, the results are not sensitive for small variations in this parameter. The tabulated values are based on $\beta = 0.99$.

In general the results are consistent with those reported in Table 5a. The implied estimates of the length between price adjustments varies between 2.5 to 3 quarters, and between 60 to 84% of firms appear to adjust prices in a forward looking manner.

4.4 Marginal cost versus the output gap in the Phillips curve

As pointed out in Section 4.1, under certain circumstances, the output gap and marginal cost are proportional to each other. In this case the estimates of the Phillips curve should be the same (up to a factor of proportionality for c_2) if a measure of the output gap replaces our marginal cost measure in the regression. Table 7 contains the corresponding coefficient estimates for inflation measured by the GDP

[10] For example, if $\omega = \theta = 0.5$ and if the discount rate is 8% per year then $c_3 + c_4 = 0.995$.

[11] In view of the sensitivity of the estimation results for the CPI inflation rate reported in Table 5b, we only carried out these estimations for the GDP deflator.

[12] The highly non-linear form of the estimated equation seems to be a problem in general. Convergence was sometimes not achieved when slight variations in the number of lags of the instruments were introduced. Conversely, when lag 2 on the nominal wage rate was removed in the second row of the table, convergence was achieved and the point estimates for θ and ω were 0.65 and 0.27 respectively.

deflator.[13] In each case, the output gap has been generated using a Hodrick-Prescott filter on a quarterly real GDP to estimate a series for potential output. As with the estimates using the marginal cost measure, the coefficients take plausible values and are relatively stable across equations. The implied values for θ suggest price adjustments on average every 2 to 2.7 quarters, similar to the values obtained with marginal cost as the driving variable. The estimates with the output gap imply somewhat more forward-looking behavior, however. All in all, based on these results it is not possible to differentiate categorically between the two specifications.

In an attempt to distinguish between the marginal cost and the output specifications we finally present results from estimates of what might be called an Old Phillips curve model of the form

$$\pi_t = c_1 + c_2 s_{t-1} + \sum_{i=1}^{3} c_{3i} \pi_{t-i} \tag{5}$$

where the variable s will be either the output gap as or what we call the price gap. The latter is simply the error from the cointegration equation used in the VECs of section 4.1 and in the GMM estimations in Tables 5a and 5b. From the results (Table 8) we draw two conclusions. First, in terms of the goodness of fit the Old Phillips curve compares favorably with the New Phillips curve estimated above. This may be a result of the imprecision that is associated with measuring expectations, and does not necessarily mean a rejection of the notion that expectations are at least partially forward-looking. Secondly, what we call the price gap has a stronger effect on inflation than the output gap. It appears therefore that the hypothesis that we have emphasized in this paper, namely that price adjustment occurs as a result of changes in the cost of production rather than as a response to changes in demand, is consistent with the data.

5. Conclusions

Inflation in a country with a currency board arrangement is usually believed to be highly dependent on external factors. Important questions for understanding the dynamics of inflation are (i) how best to measure these factors and (ii) how to model the transmission mechanism. We have brought some evidence on both. We have emphasized that general inflation rates (measured for example by CPI inflation) in foreign countries are not adequate. This is particularly the case if one looks at only the United States, even though the HKD is fixed to the USD, but it holds more generally also for multilateral indices of foreign inflation.

Concerning the transmission mechanism we have provided evidence that a Phillips curve relationship can be identified for Hong Kong. When a so-called New Phillips curve is estimated for the GDP deflator, a significant forward-looking component to expectations is identified. In addition, the estimates reveal that prices are relatively flexible in HK, with adjustments taking place almost twice as fast as in the United States judging by the estimates obtained in Gali and Gertler (1999).

[13] When the CPI inflation rate was used as the dependent variable the results were again poor. In two cases the coefficient estimates were outside the permissible range, and in the other two there was severe serial correlation in the estimated residuals. For these reasons, the detailed results are not reported.

But a more traditional version of the Phillips curve also fit the data quite well in Hong Kong. In fact, in some respects it explains the data better than the New Phillips curve. Even in this traditional specification, however, measures based on changes in production cost outperform measures of excess demand as forcing variables.

Having found that production costs are important for inflation is not the end of the story, however. To have a full explanation of the inflation process we need to have explanations for the driving forces behind changes in the cost of main factors of production, in particular wages and rental rates. This remains for future research.

References

Calvo, Guillermo A. (1983), "Staggered Prices in a Utility-Maximising Framework," *Journal of Monetary Economics*, 12: 383-98.

Cheung, Yin-Wong (2000), "Hong Kong Output Dynamics: An Empirical Analysis," Hong Kong Institute for Monetary Research Working Paper, No.11/2000

Cheung, Yin-Wong and Yuen, Jude (2001), "Effects of U.S. Inflation on Hong Kong and Singapore," Hong Kong Institute for Monetary Research Working Paper, No.3/2001

Devereux, Michael B. and Yetman, James (2002), "Price Setting and Exchange Rate Pass-through: Theory and Evidence," Hong Kong Institute for Monetary Research Working Paper, No.22/2002

Fuhrer, Jeffrey (1997), "The (Un)Importance of Forward-Looking Behavior in Price Specifications," *Journal of Money, Credit, and Banking*, 29: 338-50.

Fuhrer, Jefferey and Moore, George R. (1995), "Inflation Persistence," *Quarterly Journal of Economics*, 110: 127-59.

Gali, Jordi and Gertler, Mark (1999), "Inflation dynamics: A structural econometric analysis," *Journal of Monetary Economics*, 44: 195-222.

Ha, Jimmy and Leung Cynthia (2001), "Estimating Hong Kong's Output Gap and Its Impact on Inflation," Hong Kong Monetary Authority Research Memoranda, Economic Research Division, Research Department, November.

Ha, Leung and Shu (2002), "A Small Macroeconomic Model of Hong Kong," Hong Kong Monetary Authority Research Memoranda, Economic Research Division, Research Department, June.

Pauwels, Laurent (2002), "Inflation Dynamics in Hong Kong, SAR: The New Keynesian Phillips Curve & the use of the Generalised Method of Moments," The Graduate Institute of International Studies, Mémoire de D.E.S., October.

Rotemberg, Julio J. and Woodford, Michael (1997), "An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy," *NBER Macroeconomic Annual*, MIT: 297-346.

Rotemberg, Julio J. and Woodford, Michael (1998), "Interest-Rate Rules in an Estimated Sticky Price Model," NBER Working Paper, No. 6618, June.

Taylor, John B. (1980), "Aggregate Dynamics and Staggered Contracts," *Journal of Political Economy*, 88: 1-23.

Table 1. Shares of major trading partners in Hong Kong exports and imports

	Import shares		Shares of domestic exports	
Country	1987	1996	1987	1996
Mainland China	31.1	37.1	14.3	29.0
Japan	19.0	13.6	4.9	5.3
Taiwan	8.8	8.0		
USA	8.5	7.9	37.3	25.4
Singapore	3.8	5.3		
Germany			7.6	5.4
United Kingdom			6.6	5.0
Other	28.8	28.1	29.3	30.0
Total	100.0	100.0	100.0	100.0
of which Asia	72.5	75.6	26.6	50.0

Source: Hong Kong Annual Digest of Statistics.

Notes: Re-exports are not included in these figures.

Table 2. Unit root properties of the data[1]

	Sample period	
Variable[2]	1984:1 - 1997:1	1984:1 - 2001:4
CPI^{HK}	I(2)	I(2)
$PGDP^{HK}$	I(2)	I(2)[3]
$CPI^{U.S.}$	I(2)	I(2)
CPI^{W}	I(1)[4]	I(1)
W^{HK}	I(2)	I(2)
PIM^{HK}	I(1)	I(1)
$PPROP^{HK}$	I(1)	I(1)

Notes:

(1) Based on Dickey-Fuller tests including 4 lags of the dependent variable. Inferences are made at the 95% level of significance. Unless otherwise noted, the same inferences are implied when a constant is included in the cointegration relationship and when both a constant and a deterministic trend are included.

(2) The levels of all variables are measured in terms of natural logarithms. Foreign variables have been converted to HKD units using the corresponding nominal exchange rate. For precise data definitions, see Appendix.

(3) The sample period ends at 2001:3.

(4) When a deterministic linear trend is included, the test indicates I(0).

Table 3a. Bivariate relationships[1]

Pair of variables		Sample 1984:1 - 1997:1 Cointegration	Granger Causality	VAR or VEC relationships	Sample 1984:1 - 2001:4[2] Cointegration	Granger Causality	VAR or VEC relationships
$D(CPI^{HK})$	$D(CPI^{U.S.})$	Trace: None (1%), Two (5%) Max-E: None With Trend: One	None	VAR: No significant interaction VEC: U.S. influences HK	None	None	No significant interaction
$D(PGDP^{HK})$	$D(CPI^{U.S.})$	None (1%) Two (5%) With trend: None	None	No significant interaction	None	None	No significant interaction
CPI^{HK}	$CPI^{U.S.}$	Two (5%) With trend: One	U.S. → HK	U.S. influences HK in both VAR and VEC	None	None	Weak effect of U.S. on HK
$PGDP^{HK}$	$CPI^{U.S.}$	None	U.S. → HK (10%)	U.S. influences HK in VAR	None	None	No significant interaction
CPI^{HK}	CPI^{W}	None With trend: One	HK → World World → HK (10%)	Some influence of World on HK in both VAR and VEC	One With trend: Trace: None Max-E: One	World → HK HK → World (6%)	Evidence of mutual dependence
$PGDP^{HK}$	CPI^{W}	None With trend: One	HK → World	No significant interaction	One (5%) With trend: None	HK → World	Some influence of HK on World in both VAR and VEC

Notes:

(1) All tests are carried out with 4 lags.

(2) For tests involving PGDP the sample ends in 2001:3.

Table 3b. Bivariate relationships (cont.)[1]

Pair of variables		Sample period 1984:1 - 2001:4[2]		
		Cointegration	Granger Causality	VAR or VEC relationships
$PGDP^{HK}$	PIM^{HK}	Two (5%) One (1%) With trend: Trace: One (5%) Max-E: None	$PIM^{HK} \rightarrow PGDP^{HK}$	Import prices influence GDP deflator in VAR and VEC
$PGDP^{HK}$	W^{HK}	None	$W^{HK} \rightarrow PGDP^{HK}$	Wages influence GDP deflator in VAR
CPI^{HK}	PIM^{HK}	Two With trend: One	$PIM^{HK} \rightarrow CPI^{HK}$ $CPI^{HK} \rightarrow PIM^{HK}$	Import prices influence CPI in VAR and VEC
CPI^{HK}	W^{HK}	None With trend: Trace: One Max-E: None	$W^{HK} \rightarrow CPI^{HK}$ $CPI^{HK} \rightarrow W^{HK}$ (6%)	Wages influence CPI in VAR and VEC
W^{HK}	PIM^{HK}	None	$W^{HK} \rightarrow PIM^{HK}$ $PIM^{HK} \rightarrow W^{HK}$	Import prices influence wages in VAR
$PGDP^{HK}$	$PPROP^{HK}$	Trace: One Max-E: None With trend: Trace: None Max-E: One	$PGDP^{HK} \rightarrow PPROP^{HK}$	GDP deflator influences property prices in VAR and VEC
CPI^{HK}	$PPROP^{HK}$	None	$PPROP^{HK} \rightarrow CPI^{HK}$ $CPI^{HK} \rightarrow PPROP^{HK}$ (8%)	Mutual dependence
W^{HK}	$PPROP^{HK}$	None	$W^{HK} \rightarrow PPROP^{HK}$	Property prices influence wages in VAR
PIM^{HK}	$PPROP^{HK}$	Two (5%) One (1%) With trend: None	$PIM^{HK} \rightarrow PPROP^{HK}$	Some influence of import prices on property prices in VAR, somewhat stronger in VEC

Notes:

(1) All tests are carried out with 4 lags.

(2) For tests involving PGDP the sample ends in 2001:3.

Table 4a. Tests of cointegration between GDP deflator and marginal cost variables

Number of lags of 1st differences	Cointegration test results	Cointegration vector		Adjustment coefficient	
1	Trace: One at 5% and 1% Max-e: One at 5% and 1%	β_1	0.53 (0.03)	$\Delta\ln(P^{GDP})$	-0.24 (0.05)
		β_2	0.24 (0.05)	$\Delta\ln(P^{IM})$	0.04 (0.04)
		β_3	0.23 (0.02)	$\Delta\ln(w)$	-0.06 (0.03)
		$\Sigma\beta_i = 1$: p-value = 0.14		$\Delta\ln(P^{PROP})$	0.35 (0.27)
3	Trace: One at 5% Max-e: One at 5%	β_1	0.45 (0.03)	$\Delta\ln(P^{GDP})$	-0.29 (0.09)
		β_2	0.38 (0.05)	$\Delta\ln(P^{IM})$	0.20 (0.07)
		β_3	0.18 (0.02)	$\Delta\ln(w)$	0.03 (0.05)
		$\Sigma\beta_i = 1$: p-value = 0.46		$\Delta\ln(P^{PROP})$	0.71 (0.45)
5	Trace: One at 5% and 1% Max-e: One at 5% and 1%	β_1	0.50 (0.10)	$\Delta\ln(P^{GDP})$	-0.49 (0.10)
		β_2	0.31 (0.05)	$\Delta\ln(P^{IM})$	-0.04 (0.09)
		β_3	0.19 (0.02)	$\Delta\ln(w)$	-0.01 (0.06)
		$\Sigma\beta_i = 1$: p-value = 0.51		$\Delta\ln(P^{PROP})$	-0.47 (0.54)

Notes: The cointegration equation is $\ln(P^{GDP}) = \beta_1 \cdot \ln(P^{IM}) + \beta_2 \cdot \ln(w) + \beta_3 \cdot \ln(P^{PROP})$

Table 4b. Tests of cointegration between CPI and marginal cost variables

Number of lags of 1st differences	Cointegration test results	Cointegration vector		Adjustment coefficients	
1	Trace: Three at 5% and one 1% Max-e: One at 5% and 1%	β_1	0.44 (0.02)	$\Delta \ln(CPI)$	-0.14 (0.03)
		β_2	0.37 (0.04)	$\Delta \ln(P^{IM})$	-0.04 (0.04)
		β_3	0.19 (0.02)	$\Delta \ln(w)$	-0.11 (0.02)
		$\Sigma\beta_i = 1$: p-value = 0.17		$\Delta \ln(P^{PROP})$	0.26 (0.23)
3	Trace: Two at 5% and one at 1% Max-e: One at 5%	β_1	0.41 (0.02)	$\Delta \ln(CPI)$	-0.16 (0.04)
		β_2	0.42 (0.04)	$\Delta \ln(P^{IM})$	-0.10 (0.06)
		β_3	0.17 (0.02)	$\Delta \ln(w)$	-0.13 (0.03)
		$\Sigma\beta_i = 1$: p-value = 0.97		$\Delta \ln(P^{PROP})$	0.05 (0.42)
5	Trace: Two at 5% and two at 1% Max-e: Two at 5% and one at 1%	β_1	0.46 (0.03)	$\Delta \ln(CPI)$	-0.19 (0.05)
		β_2	0.32 (0.05)	$\Delta \ln(P^{IM})$	-0.09 (0.07)
		β_3	0.23 (0.03)	$\Delta \ln(w)$	-0.11 (0.04)
		$\Sigma\beta_i = 1$: p-value = 0.42		$\Delta \ln(P^{PROP})$	-0.22 (0.48)

Notes: The cointegration equation is $\ln(CPI) = \beta_1 \cdot \ln(P^{IM}) + \beta_2 \cdot \ln(w) + \beta_3 \cdot \ln(P^{PROP})$

Table 5a. GMM estimates of equation (4). Dependent variable $\Delta \ln(P^{GDP})$

Lag length of instruments	c_2	c_3	Implied values of θ and ω (β=0.99)
1	0.044 (0.061)	0.53 (0.08)	$\theta = 0.65$ $\omega = 0.56$
2	0.064 (0.047)	0.61 (0.06)	$\theta = 0.66$ $\omega = 0.42$
3	0.128 (0.047)	0.60 (0.05)	$\theta = 0.57$ $\omega = 0.37$
4	0.092 (0.026)	0.51 (0.05)	$\theta = 0.55$ $\omega = 0.54$

Notes: The estimated equation is $\Delta_1 \ln(P^{GDP}) = c_1 + c_2(0.45\ln(P^{IM}) + 0.38\ln(w) + 0.17\ln(P^{PROP}) - \ln(P^{GDP})) + c_3\, \Delta_4 \ln(P^{GDP})_{t+4} + (1-c_3)\, \Delta_1 \ln(P^{GDP})_{t-1}$. Instruments are lagged values of $\Delta_1 \ln(P^{IM})$, $\Delta_1 \ln(w)$, $\Delta_1 \ln(P^{PROP})$, $\Delta_1 \ln(P^{GDP})$, $\Delta_1 \ln(CPI^{world})$.

Table 5b. GMM estimates of equation (4). Dependent variable $\Delta\ln(P^{CPI})$

Lag length of instruments	c_2	c_3	Implied values of θ and ω (β=0.99)
1	-0.019 (0.031)	0.84 (0.06)	....
2	0.14 (0.04)	10.09 (0.05)	....
3	0.13 (0.02)	0.69 (0.04)	θ = 0.61 ω = 0.27
4	0.026 (0.009)	0.41 (0.04)	θ = 0.57 ω = 0.81

Notes: The estimated equation is $\Delta_1\ln(P^{CPI}) = c_1 + c_2(0.41\ln(P^{IM}) + 0.42\ln(w) + 0.17\ln(P^{PROP}) - \ln(P^{GDP})) + c_3\,\Delta_4\ln(P^{CPI})_{t+4} + (1-c_3)\,\Delta_1\ln(P^{CPI})_{t-1}$. Instruments are lagged values of $\Delta_1\ln(P^{IM})$, $\Delta_1\ln(w)$, $\Delta_1\ln(P^{PROP})$, $\Delta_1\ln(P^{GDP})$, $\Delta_1\ln(CPI^{world})$.

Table 6. GMM estimates of equation (4). Dependent variable $\Delta\ln(P^{GDP})$

Lag length of instruments	θ	ω
1*	0.59 (0.10)	0.40 (0.09)
2**	....	....
3	0.54 (0.07)	0.25 (0.04)
4	0.65 (0.06)	0.16 (0.05)

Notes: The estimated equation is $\{\theta + \omega[1-\theta(1-\beta)]\}\Delta_1\ln(P^{GDP}) = c_1 + (1-\omega)(1-\theta)(1-\beta\theta)\,[0.45\ln(P^{IM}) + 0.38\ln(w) + 0.17\ln(P^{PROP}) - \ln(P^{GDP})] + \beta\theta\Delta_4\ln(P^{GDP})_{t+4} + \omega\Delta_1\ln(P^{GDP})_{t-1}$ with β constrained to 0.99. Instruments are lagged values of $\Delta_1\ln(P^{IM})$, $\Delta_1\ln(w)$, $\Delta_1\ln(P^{PROP})$, $\Delta_1\ln(P^{GDP})$, $\Delta_1\ln(CPI^{world})$.

* Convergence failed after 500 iterations. The results refer to the inclusion of 2 lags of the dependent variable.

** The parameter estimates were not in the permissible range. Severe serial correlation in the residuals.

Table 7. GMM estimates with the output gap replacing marginal cost. Dependent variable $\Delta\ln(P^{GDP})$

Lag length of instruments	c_2	c_3	Implied values of θ and ω (β=0.99)
1	0.24 (0.10)	0.71 (0.11)	θ = 0.53 ω = 0.21
2	0.19 (0.07)	0.89 (0.07)	θ = 0.63 ω = 0.08
3	0.10 (0.02)	0.76 (0.04)	θ = 0.67 ω = 0.21
4	0.12 (0.02)	0.72 (0.04)	θ = 0.63 ω = 0.23

Notes: The estimated equation is $\Delta_1\ln(P^{GDP}) = c_1 + c_2 ygap_t + c_3\,\Delta_4\ln(P^{GDP})_{t+4} + (1-c_3)\,\Delta_1\ln(P^{GDP})_{t-1}$. Instruments are lagged values of $\Delta_1\ln(P^{IM})$, $\Delta_1\ln(w)$, $\Delta_1\ln(P^{PROP})$, $\Delta_1\ln(P^{GDP})$, $\Delta_1\ln(CPI^{world})$.

Table 8. OLS estimates of equation (6)

	Dependent variable: $\Delta_1\ln(P^{GDP})$			Dependent variable: $\Delta_1\ln(P^{CPI})$		
	s-variable			s-variable		
	pricegap	ygap	both	pricegap	ygap	both
c_{2p}	0.29 (0.05)		0.27 (0.06)	0.14 (0.02)		0.14 (0.02)
c_{2y}		0.14 (0.05)	0.03 (0.05)		0.05 (0.03)	0.03 (0.02)
c_{31}	0.07 (0.11)	0.15 (0.12)	0.07 (0.11)	-0.04 (0.10)	0.24 (0.12)	-0.06 (0.10)
c_{32}	0.27 (0.10)	0.37 (0.11)	0.27 (0.10)	0.04 (0.10)	0.27 (0.12)	0.04 (0.10)
c_{33}	0.15 (0.10)	0.19 (0.12)	0.15 (0.11)	0.30 (0.10)	0.46 (0.12)	0.34 (0.10)
R^2	0.61	0.50	0.61	0.86	0.77	0.86

Figure 1. Hong Kong price levels (log scale)

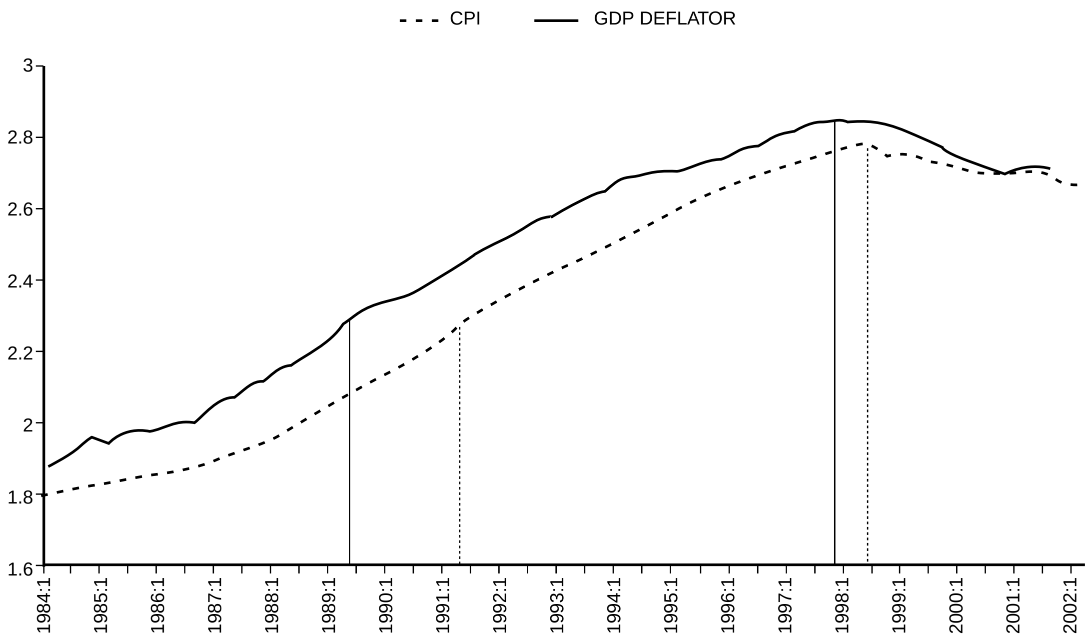


Figure 2. U.S. CPI and HK GDP deflater (log scale)

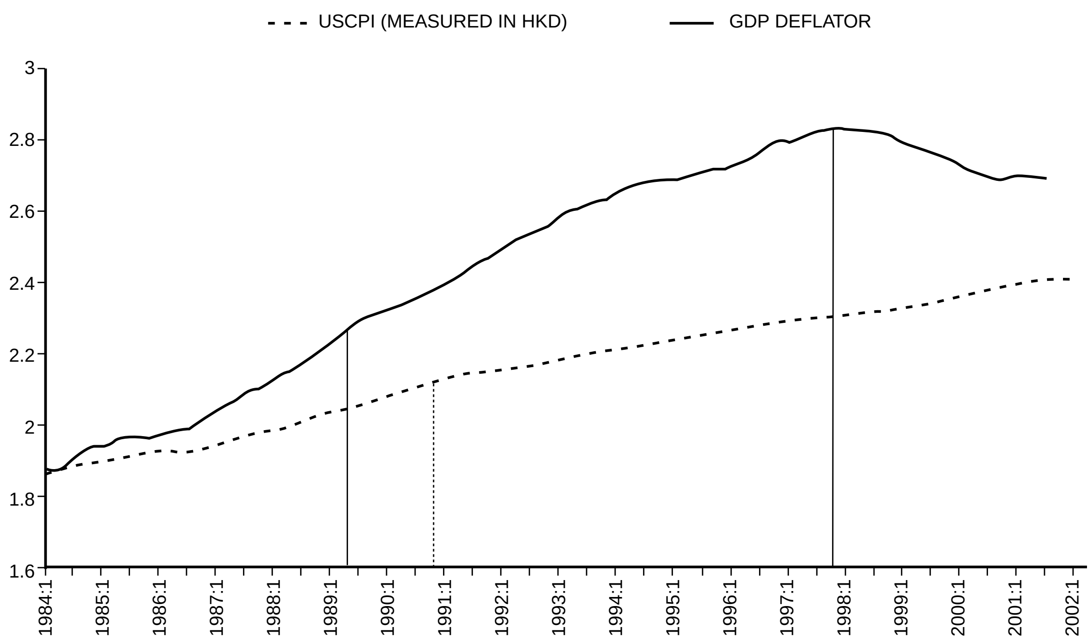


Figure 3. GDP Deflator, 'World' Prices and Import Prices

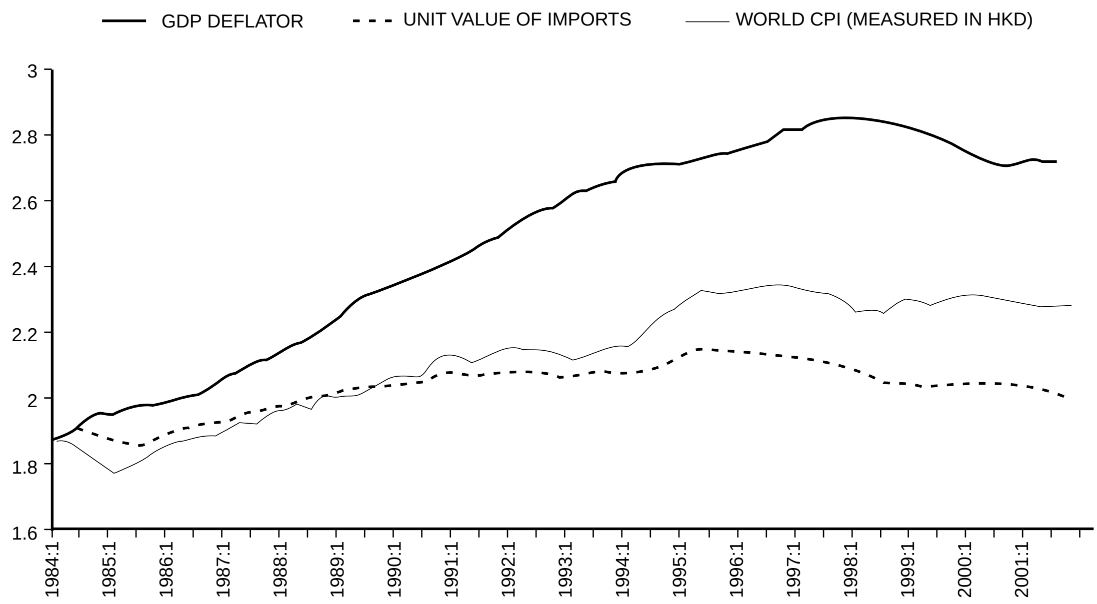


Figure 4. Exchange rates of the Hong Kong Dollar

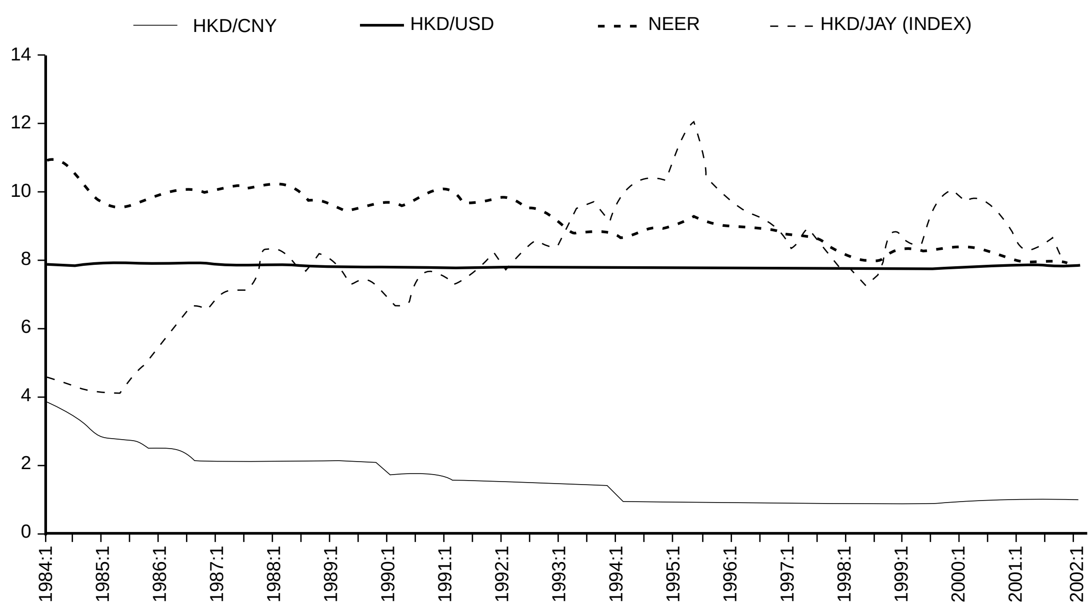


Figure 5. Dynamic solutions, VEC with 3 lags

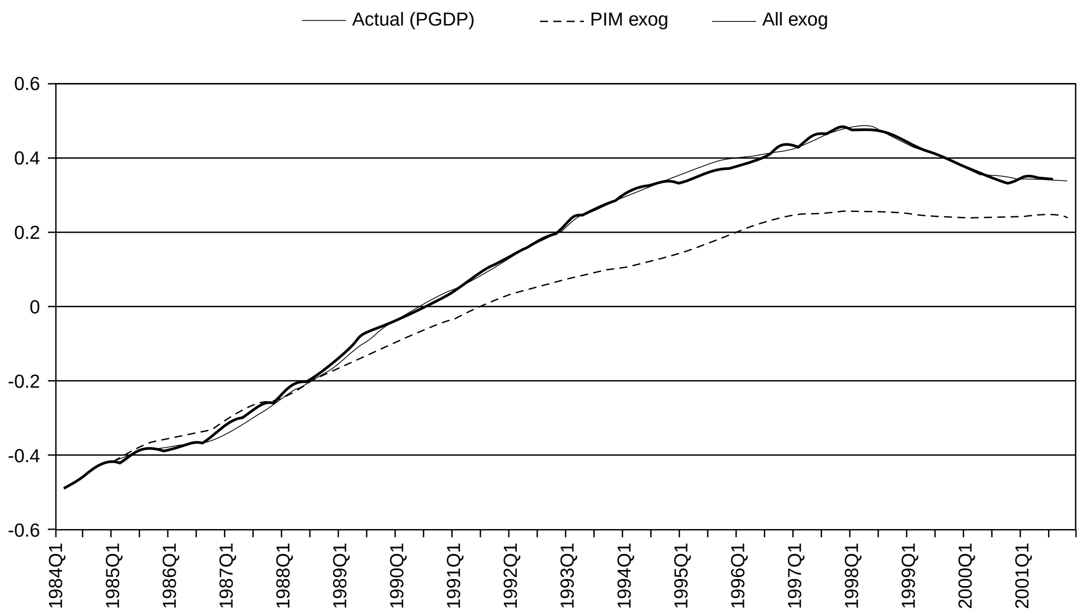
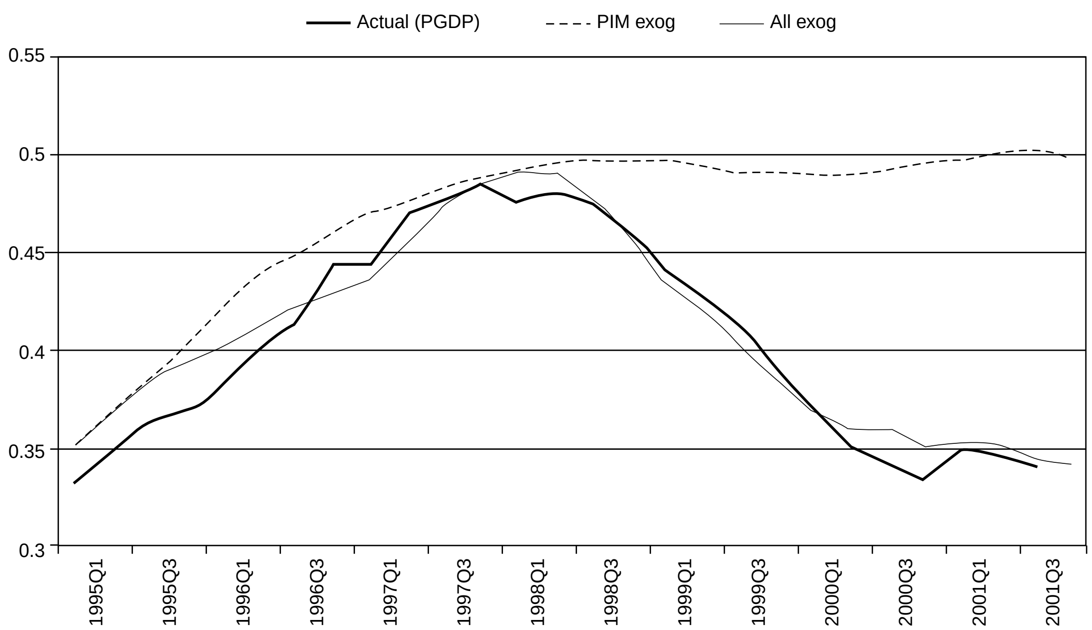


Figure 6. Dynamic solutions from 1995:1, VEC with 3 lags



Appendix: Data definitions and sources

Data

The quarterly sample period spans from the first quarter of 1984 to the fourth quarter of 2001. Most of the data was retrieved from the Hong Kong Monetary Authority internal database and some from the CEIC database to which the Hong Kong Institute for Monetary Research has subscribed.

Seasonal Adjustment

All the variables used as such and to generate other measures have been adjusted for seasonality using the X-12 method created by the U.S. Bureau of Census.[14]

Natural Logarithm

All variables are measured in natural logarithm.

1. GDP Deflator ($PGDP^{HK}$)

The deflator is constructed dividing nominal by real (at 1990 prices) GDP, both seasonally adjusted before hand.

2. Hong Kong CPI (CPI^{HK})

The measure for the CPI refers to the CPI (A) which measures the average change in the prices of a basket of goods and services typical of a household whose monthly expenditure is between $4000 and $16000 (covering about 1/2 of HK households). (10/99-9/00=100)

3. U.S. CPI ($CPI^{U.S.}$)

The U.S. CPI is adjusted in HKD using HKD/USD rate from the Hang Seng Bank (1982-84=100).

4. World CPI (CPI^{W})

World prices are derived from the 14 largest trading partners to Hong Kong (1990=100) and adjusted in HKD using the nominal effective exchange rate index (NEERI, Nov 83=100).

5. Nominal Wages (W^{HK})

Nominal wages are based on a seasonally adjusted nominal wage index (Sep 1992=100).

6. Import Prices (PIM^{HK})

Import prices are based on the seasonally adjusted quarterly Unit Value Index of Imports (1990=100).

7. Property Prices ($PPROP^{HK}$)

The property price variable is generated using residential property prices (1999=100), rather than office or retail property prices due to availability problems of this data.

8. Output gap

The output gap $(y\text{-}y^n)$ is created using a Hodrick-Prescott filter (with a smoothing coefficient of 1600) on seasonally adjusted real GDP to generate potential output and then subtracted from real GDP.

---

14 Refer to U.S. Census Bureau at http://www.census.gov