Hong Kong Monetary Authority

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ESTIMATING HONG KONG'S OUTPUT GAP AND ITS IMPACT ON INFLATION

Key Points:

- *Growth slowed significantly in recent years, from an average annual rate of 7 percent between 1977-94 to 3½ percent between 1995-2000. Inflation decelerated during the same period, falling from double-digit levels in the early 1980s and turned negative in recent years. This paper looks into the reasons behind the recent slowdown in growth by examining the path of* ***potential output****, and the contributory factors to potential growth. The estimated* ***output gap****—the difference between the actual and the estimate of potential output—is employed along with the domestic import price to examine the dynamics of inflation.*

- *The empirical results suggest that* ***growth of potential output slowed over the past two and a half decades****, decelerating from an average annual rate of 8% around early 1980s to 3½ - 4% in the aftermath of the Asian financial crisis.* ***However****,* ***potential growth has been on the high side, compared to the G-7 countries****. The negative output gap, which emerged during 1998-99, virtually vanished following a sharp growth rebound in 2000. In view of weak external demand and the growth performance so far this year, a negative output gap is likely to re-emerge in 2001.*

- *Regarding the sources of growth, our results suggest that* ***capital formation accounted for 40-50% of output growth and labour and total factor productivity each accounted for 25-30% of growth during 1977-2000,*** *similar to the most advanced economies of the world.*

- *The analysis of inflation indicates that a positive output gap of 1 percentage point pulls inflation up by ½ percentage point in the short run and 2½ percentage point in the long run. An increase in the domestic price of imports by 1 percentage point pushes inflation up by ¼ percentage points in the short run, with a full pass-through effect in the long run****. The nominal effective exchange rate,*** *which has appreciated by 25% since the adoption of the linked exchange rate system,* ***served as an effective nominal anchor to contain inflation through the effect on domestic price of imports****.*

- *Computation of a measure of full-employment inflation suggests that the price level diverged from the equilibrium path through 1997****. Nevertheless, prices declined sharply during 1998-2000, bringing their level back to the equilibrium path by 2000****. This implies that the current deflation process is mainly a cyclical rather than a structural phenomenon. However, deflation is likely to continue in the immediate future due to a possible re-emergence of negative output gap in 2001 and the long-run effect of the negative gaps of 1998-2000.*

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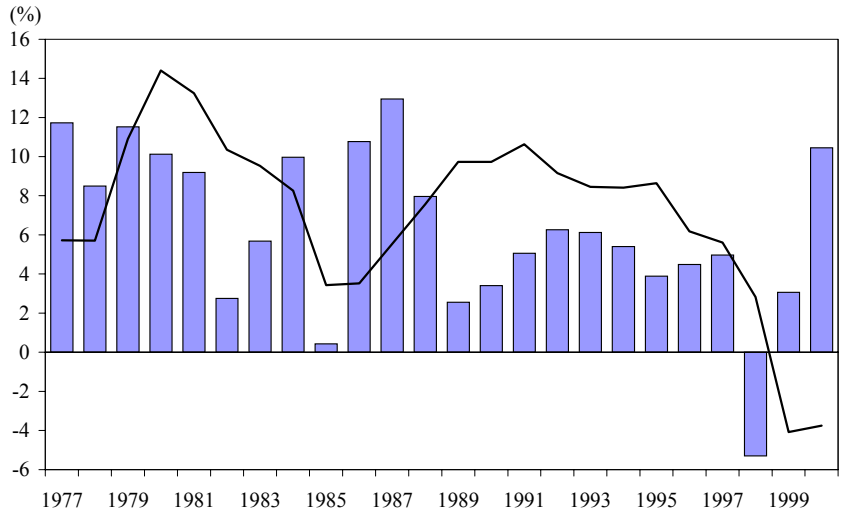
I. INTRODUCTION

Hong Kong achieved remarkable economic growth in the past two and a half decades, with annual real GDP growth averaging over 6 percent during 1977-2000 (Chart 1). However, growth decelerated significantly in recent years, from an annual average of 7% between 1977-94 to 3½% between 1995-2000. This raises several important issues. Does the recent economic downturn reflect a downward cyclical adjustment, or a shift in the potential growth path? What are the major contributory factors to Hong Kong's growth performance? How and to what extent has output gap affected the inflation (deflation) process along with other variables? Is the ongoing deflation process a cyclical phenomenon or a structural one?

Chart 1. Real GDP Growth and Inflation



The paper addresses these issues by estimating potential output, decomposing sources of growth, and assessing the inflationary impact of output gap—the difference between actual and potential output. The rest of the paper is organised as follows. Section II provides a brief review of the literature. Section III discusses the basic framework of the production function approach to estimating potential output. Section IV presents estimation results of the production function and the output gap, and compares the results with those derived from two alternative methods and the estimates included in the IMF's *World Economic Outlook*. Section V studies the contributions of factor inputs and technology progress during the past two and a half decades, and compares the results with previous studies on Hong Kong and other economies. Section VI examines the dynamics of inflation in relation to the output gap and import prices. Section VII provides concluding remarks.

II. A BRIEF LITERATURE REVIEW

There has been a substantial body of literature on the methodologies to estimating potential output, because measures of the size and persistence of output gaps provide a useful guide to analysing the short-term imbalance between supply and demand, and its inflationary impact. Moreover, measures of potential output—which embody

information of trend developments in production inputs and technological progress—provide a useful tool for examining the aggregate supply capacity of an economy and for assessing sustainable paths of non-inflationary growth. The most commonly used methods for estimating output gaps include the production function approach (Young (1995), Sarel (1997), and Roldos (1997)), univariate filters approach (e.g., Hodrick-Prescott filter) (Dodsworth and Mihaljek (1997), and Scacciavillani and Swagel (1999)), and multivariate time-series methods (e.g., VAR and Kalman filter). While each of these approaches has its advantages and disadvantages, this paper adopts the production function approach for the following reasons. First, by relating potential output to its determinants, it produces estimate of potential output that is less sensitive to cyclical fluctuations of actual output; Secondly, it provides a useful tool for decomposing various sources of growth through "growth accounting". Finally, it provides empirical estimates of marginal productivity of factor inputs, which can be used to calculate total factor productivity (TFP) and test the hypothesis of increasing returns to scale—a key ingredient of endogenous growth theories.[1]

On the relationship between output gap (employment gap) and inflation, most empirical studies are based on the Phillips curve, and the results have been inconclusive. Coe and McDermott (1996) find close relationships between output gap and inflation in several Asian countries. IMF (1996) and Roldos (1997) argue that in most Latin American countries neither current nor lagged output gaps show any significant correlation with inflation, as these countries experienced hyperinflation that was often accompanied by slow or negative growth.

III. THE BASIC FRAMEWORK

We use a basic growth accounting framework to measure the contribution of factor inputs and technology progress to output growth. The analysis begins with a Cobb-Douglas production function, which defines output (Y) as a function of technology progress (A), capital input (K), and labour input (L)

$$Y_t = AK_t^{\alpha} L_t^{\beta}, \qquad (1)$$

where $0 < \alpha, \beta < 1$ are marginal productivity of capital and labour respectively, and A denotes technology progress.

Two types of methods are widely used to estimate the parameters of Cobb-Douglas production function: an econometric and a "national accounts" approach. Both methods have their advantages and disadvantages. The latter derives shares of capital and labour from national accounts to estimate marginal productivities of factor inputs. It relies on the assumption that marginal productivities of capital (α) and labour (β) in equation (1) represent unbiased estimates of factor shares. However, this approach suffers from a number of drawbacks. First, it imposes the restriction that capital and labour markets are perfectly competitive so that the return to each factor of production is equal to the value of

[1] Endogenous growth theories have attempted to endogenise TFP growth through a variety of channels, including technology diffusion from international trade (Grossman and Helpman (1991), Rivera-Batiz and Romer (1991)), externalities from public expenditure, and R&D spending (Barror and Sala-i-Martin (1995)). A salient feature of endogenous growth models is the existence of increasing returns to scale.

its marginal productivity. Secondly, it ignores effects of government policies and regulations, such as tax policy.[2] Finally, it imposes the assumption of constant returns to scale, and the hypothesis of increasing returns to scale—a key element of endogenous growth theories—cannot be tested within the framework. The econometric approach avoids the above drawbacks of the national accounts approach, but the results could be sensitive to the estimates of capital stock, which is an unobservable variable and its estimation is prone to measurement errors when reliable data on capital depreciation and utilization are not available. The econometric approach can complement the national accounts approach in the sense that the results of statistical tests on the hypothesis of constant returns to scale derived from the econometric approach can be used to check the validity of the national accounts approach.

In estimating potential output, the cyclical components of TFP and employment need to be removed. A common practice is to apply the Hodrick-Prescott (HP) filter to smooth the TFP series and the cyclical component of employment. In empirical work, because of the long adjustment lags involved, the actual and trend level of the capital stock are often assumed to be the same. By smoothing TFP and factor inputs rather than output, the production function approach provides a useful tool for analysing the contributions of TFP and factor inputs. Growth accounting is carried out to study the sources of growth by weighing the changes in inputs by the estimates of marginal productivity. Finally, we study the relationship between inflation and output gap by estimating a Phillips curve, which is augmented by import prices in Hong Kong dollar terms.

IV. POTENTIAL OUTPUT ESTIMATES

In this section, we present empirical estimates of the parameters of the Cobb-Douglas production function as specified in equation (1), and calculate potential output by combining the estimated parameters with smoothed series of the TFP and factor inputs.

a. Estimation of Production Function

In view of low tax rates, competitive factor markets, and lack of information for constructing reliable data on the capital stock in Hong Kong, we use the national accounts approach to estimate factor shares. We also estimate the production function using the econometric approach, and report the results in Annex A. It is important to note that the hypothesis of constant returns to scale cannot be rejected in our econometric analysis, adding support to the use of the national accounts approach.

A number of studies have estimated factor shares in Hong Kong and other economies, using the national accounts approach. Young (1995) finds that the share of capital in Hong Kong is 37%. Sarel (1997) and Easterly (2001) show that the share of capital is about 30% in a number of Asian countries (except Singapore) and around 40% in the United States, the United Kingdom, and Japan. We set the share of capital at 35% in the following analysis.

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[2] See Sarel (1997) for details.

b. Estimation of Potential Output

We use 1997-2000 annual data on real GDP, real capital formation by the private sector, and employment from the Census and Statistics Department. The series on capital stock is constructed using perpetual inventory method as explained in Annex B. In order to estimate potential output, the cyclical components of TFP and labour input need to be removed. The smoothed series for TFP and employment are put into the production function to compute potential output.

Smoothed Series for TFP and Labour Inputs

A series of TFP growth is estimated by subtracting a weighted sum of factor inputs from output growth, using 35% and 65% as weights for capital and labour inputs, respectively. The series on TFP is smoothed using the HP filter. Two approaches are used to remove the cyclical component of the employment series. The first approach smoothes the labour input by applying the HP filter to the actual employment figures. The second approach uses the natural unemployment rate as estimated in a structural model by Peng, Cheung and Fan (2001). As the results from the two approaches are similar, we use full-employment series derived from the widely used HP filter in the following discussion.

Estimates of Potential Growth and Output Gap

After obtaining smoothed series for TFP and labour, potential output can be estimated through the production function. The estimated growth of potential output averaged at 6% per annum during the whole sample period (Chart 2). The average annual growth rate of potential output reached 8% during 1977-84 as the economy benefited from the economic reforms in the Mainland, and stabilised at around 5¼% during 1985-1997 as the economy was maturing. However, following the Asian financial crisis, potential growth decelerated to 3½ - 4% due to slower investment and higher natural unemployment rate.[3]

Output gaps were generally positive for more than a decade between mid-1980s and mid-1990s when actual annual growth averaged over 6½%, but turned negative in the aftermath of the Asian financial crisis (Chart 2). Although the negative output gap narrowed significantly due to a sharp growth rebound in 2000, output was still about 1% below its potential by 2000.

It is useful to compare our estimates with those derived from alternative methods. Chart 2 also presents estimates of the HP-filter and Kalman-filter approaches. The three estimates of the output gaps display broadly similar patterns, supporting the finding of a general slowdown in potential output growth over the sample period. The results from the three approaches uniformly indicate that the negative gap, which emerged during 1998-1999, has narrowed following a sharp rebound of growth in 2000.

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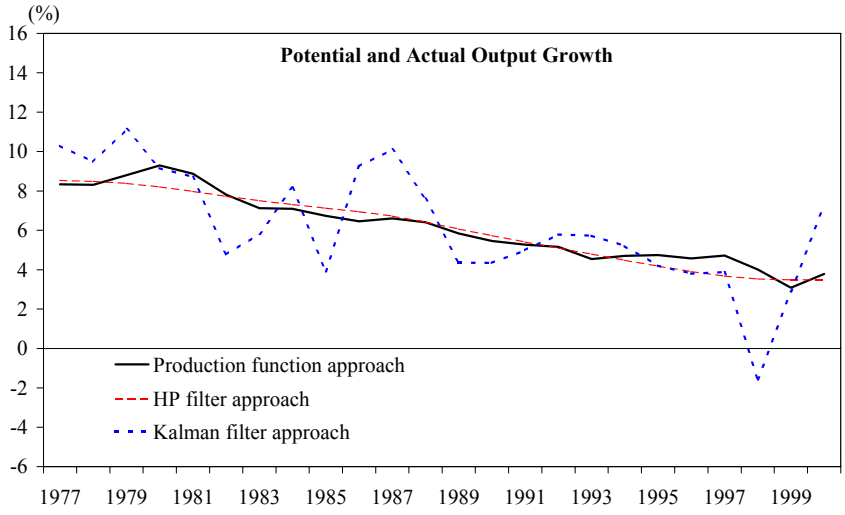
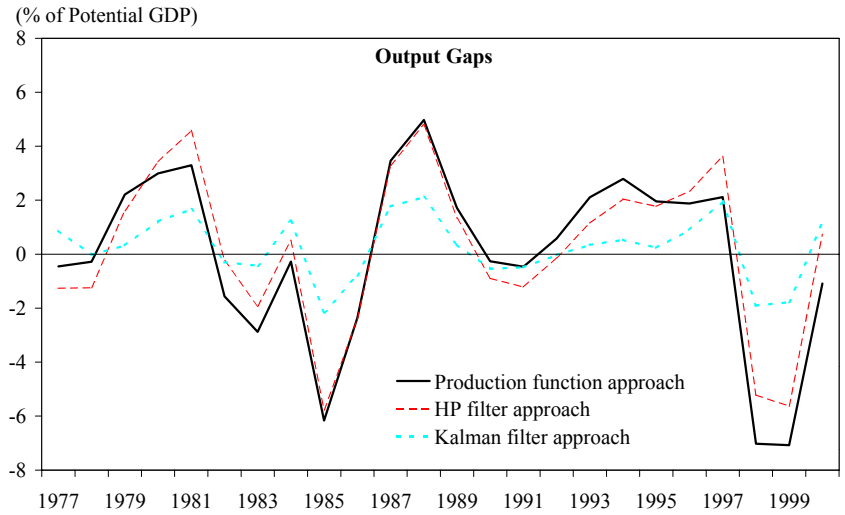
[3] Peng, Cheung and Fan (2001) find that the natural rate of unemployment edged up from 2-3% in the first part of the 1990s to 3-4% in more recent years.

Potential growth in 2000 is estimated to be around 4% by the production function and HP-filter approaches.[4]

Our estimates of potential growth rates are fairly robust, as they are not very sensitive to the estimates of capital and labour shares (see Annex A), and are consistent with the estimates in the *World Economic Outlook* published on the IMF Website (Table 1). Compared with IMF estimates of the G-7 countries and some Asia-Pacific economies, Hong Kong's potential GDP growth has been higher than the G-7 countries, but slightly lower than the Asia-Pacific countries with similar level of development.

Chart 2. Estimates of Potential Output Growth and Output Gaps





[4] A Kalman filter estimate suggests that potential growth was negative in 1998 and 7% in 2000. The results of the Kalman filter estimation are subject to controls on the variances of the state space and the observation equations.

Table 1. A Comparison with IMF's Estimates of Potential Growth
(In percent)

Country	1977-1984		1985-1997		1998-2000	
	Potential Growth	Output Gap	Potential Growth	Output Gap	Potential Growth	Output Gap
			HKMA's Estimates			
Hong Kong	7.9	0.3	5.3	1.2	3.6	-5.0
			IMF's Estimates			
Hong Kong	n.a.	n.a.	5.5	0.7	3.9	-5.1
G7						
Canada	3.4	-0.8	2.7	-2.8	3.1	-1.5
France	2.2	0.8	2.1	-1.1	2.3	-1.1
Germany	2.2	-1.1	2.2	-0.3	1.9	-1.0
Italy	2.9	0.9	2.1	-0.5	1.9	-2.3
Japan	4.4	-0.7	3.0	0.8	1.6	-2.9
United Kingdom	2.0	-1.4	2.4	0.1	2.4	0.1
United States	3.5	-1.5	3.0	-1.7	3.2	0.4
Asia-4						
Australia	2.9	0.7	3.5	0.0	4.2	0.7
Korea	6.6	-0.5	8.0	0.4	4.2	-2.7
Singapore	n.a.	n.a.	8.4 [1]	0.0 [1]	6.0	-1.3
Taiwan	8.5 [2]	0.1 [2]	7.4	-0.2	5.3	0.4

Source: HKMA's staff esimates and WEO Databases October 2001, IMF

[1] For 1987-1997 only.
[2] For 1978-1984 only.

V. DECOMPOSING THE SOURCES OF GROWTH

Decomposing the sources of growth at various stages of Hong Kong's economic development helps identify contributory factors to growth of each stage. This exercise is made possible by the estimation of the production function.

Differentiating both sides of equation (1) against time yields,

$$\frac{\Delta Y}{Y} = \frac{\Delta TFP}{TFP} + \hat{\alpha}\frac{\Delta K}{K} + \hat{\beta}\frac{\Delta L}{L} \qquad (2)$$

The three terms on the right hand side of equation (2) represent, respectively, contributions of TFP, capital, and labour. Table 2 shows the growth of potential output and its contributory factors. During the past two and a half decades, Hong Kong has evolved through three phases of developments: high growth (1977-1984), steady growth (1985-1997), and consolidation (1998-2000). Capital accounted for about 40-50% of the growth of potential output, and labour and TFP each accounted for about 25-30% of potential growth during 1977-2000.

Table 2. Hong Kong—Potential Growth and Sources of Growth
(In percent)

	1977-1984	1985-1997	1998-2000
Annual growth of potential output	**7.9**	**5.3**	**3.6**
Annual growth of factor inputs and TFP			
Labour	3.7	1.5	1.3
Capital	8.7	7.9	5.6
TFP	2.4	1.6	0.8
Shares contributed by factor inputs and TFP			
Labour	31	18	23
Capital	39	52	55
TFP	31	30	21

Some key observations could be made from the developments of these contributory factors over the three phases. First, in late 1970s and the early 1980s, potential output grew by an average of 8% per year. The high growth rate was supported by strong capital investment, massive inflow of immigrants from China, and influx of boat refugees from Vietnam. The inflow of immigrants during this period helped the development of the manufacturing and low-end service sectors, which then accounted for an important part of the economy. In the second phase, growth of potential output stabilised at 5%-6% for a prolonged period from mid-1980s to 1997. During this period, Hong Kong's economy experienced a profound structural change, as manufacturing firms relocated their operations to low-cost production bases in China. A large number of skilled workers and professionals emigrated in late 1980s, contributing to a slowdown in growth of labour input. Yet, potential growth was maintained by increased investment as many service firms made use of labour-saving capital equipment, the price of which was growing more slowly than wages. The Airport Core Program (ACP)—the largest infrastructure program in Hong Kong's history—also contributed to the sharp rise in capital investment.[5] However, potential growth moderated to around 4% in recent years, largely due to the impact of the Asian financial crisis which leading to a lower rate of investment.

It is useful to compare our estimates with some previous studies on Hong Kong and other economies. Table 3 shows that the estimated contributions of factor inputs and TFP in comparison with those reported by the World Bank. First, our estimate that capital and labour explained 70%-80% of potential growth in Hong Kong over 1977-2000 is about the same as those obtained by Young for the period 1966-90. Secondly, growth in Hong Kong has been driven mainly by capital and TFP, similar to the findings of previous studies on the United States, United Kingdom, and Japan. Finally, the contribution of TFP declined as the economy matured—a phenomenon also found in the

[5] The ACP, which commenced in 1991 and was completed in 1998, involved a total investment of HK$155.3 billion at current prices and consisted of 10 core projects, including land formation of more than one thousand hectares and construction of a new airport.

United States and Japan. Compared with Asian economies with similar level of development, Hong Kong's productivity has played a more important role in economic growth.

Table 3. International Comparison of Sources of Growth
(In Percent)

	Share of Capital	Contribution to Growth		
		Capital	Labour	TFP
Advanced economies 1947-73				
Japan	39	35	23	42
United Kingdom	38	47	1	52
United States	40	43	24	33
Advanced economies 1960-90				
Japan	42	57	14	29
United Kingdom	39	52	-4	52
United States	41	45	42	13
Latin America 1940-80				
Argentina	54	43	26	31
Brazil	45	51	20	29
Chile	52	34	26	40
Mexico	69	40	23	37
East Asia 1966-90 [1]				
Hong Kong	37	42	28	30
Singapore	53	73	32	-5
South Korea	32	46	42	12
Taiwan	29	40	40	20

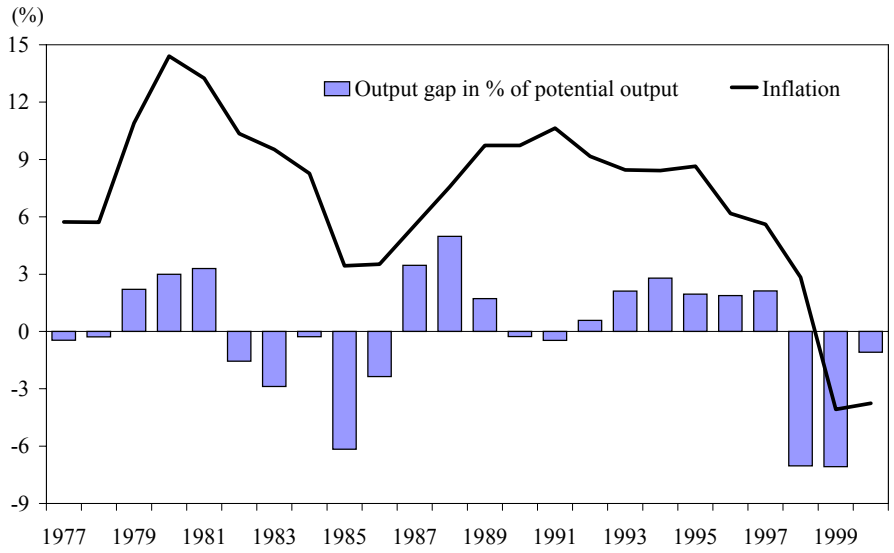
Source : World Bank

[1] Figures from Young (1995)

VI. THE RELATIONSHIP BETWEEN INFLATION AND THE OUTPUT GAP

A plausible measure of output gap should help explain developments of inflation. We have therefore studied the relationship between inflation and output gap to "cross check" the estimates of output gap. Chart 3 shows that increases (decreases) in the inflation of the past two decades had been associated with positive (negative) output gaps.

Chart 3. Inflation and Output Gap



a. Estimation of Inflation Equation

Following Stock and Watson (1999), we estimate a Phillips curve, in which the change in inflation ($\Delta\pi$) depends on its lags and current and past output gaps (*Gap*).

$$\Delta\pi_t = A(L)Gap_t + B(L)\Delta\pi_{t-1} + e_t \qquad (3)$$

where L denotes the lag operator, and A and B are polynomials of the lag operator. We estimate equation (3) using a general-to-specific modelling strategy, and found the following results.

$$\Delta\pi_t = \underset{(4.5)}{0.570}Gap_t + v_t \qquad (4)$$

$R^2 = 0.47$, and D-W Statistic = 1.65.

Equation (4) shows a positive, and statistically significant (with a t-statistic of 4.5), relationship between the changes in inflation and the estimate of output gap, suggesting that the estimate of the output gap is plausible.

The Phillips curve as specified in equations (3) and (4) implies that inflation will be constant when output reaches its potential. However, in a small open economy, inflation is affected not only by output gap, but also by other variables, including changes in the effective nominal exchange rate and the price of imports. The specification fails to characterise the path of inflation when output reaches its potential.

To better characterise inflation dynamics, we include the domestic price of imports in the regression. The modified specification should be able to capture the exchange rate pass-through effect, and help examine the determinants of inflation apart from output gaps. Again, following the general-to-specific modelling strategy, we obtain results as shown in Table 4.

Table 4. Relationship between Inflation and Output Gap

(Dependent Variable: π_t)

	Production function	HP-filter	Kalman-filter
Variable			
π_{t-1}	0.81	0.80	0.79
	(16.4)	(14.5)	(12.9)
Gap_t	0.47	0.44	0.86
	(4.4)	(3.4)	(2.3)
Δpm_t	0.25	0.27	0.29
	(3.5)	(3.3)	(3.1)
Summary statistics			
R^2	0.90	0.88	0.85
P-value of Q(1)-statistics	0.92	0.24	0.09
Test of full pass-through of import price			
P-value of F-statistics	0.25	0.30	0.28

Notes : 1. t-statistics in parentheses.

The term Δpm is the percentage change in the import price. The first column uses the estimate of output gap derived from the production function approach. All coefficients are of plausible sign and magnitude, and statistically significant. The statistical tests on serial correlation support the hypothesis of no serial correlation.

Inflation is affected through three channels in this specification: (1) past inflation, reflecting price inertia or stickiness; (2) output gap, reflecting general macroeconomic conditions; and (3) changes in the import price, reflecting shocks to the world price and/or the exchange rates of Hong Kong's trade partners vis-à-vis the US dollar.[6] Domestic price is to be affected by cumulative changes in the nominal effective exchange rate even if output reaches potential and the world price stabilises.

Main results derived from the inflation equation (Column 1, Table 4) may be summarised as follows. First, a positive output gap of one percentage pulls inflation up by ½ percentage point in the short-run and 2½ percentage point in the long run. Secondly, an increase in the import price of 1 percentage point (either due to an increase in the price denominated in foreign currency or a depreciation in the nominal effective exchange rate)

[6] We are unable to find significant explanatory power of wages and asset prices to inflation in the regression, because, unlike the import price, they are closely synchronised with the business cycles, which probably have been largely captured by the output gaps.

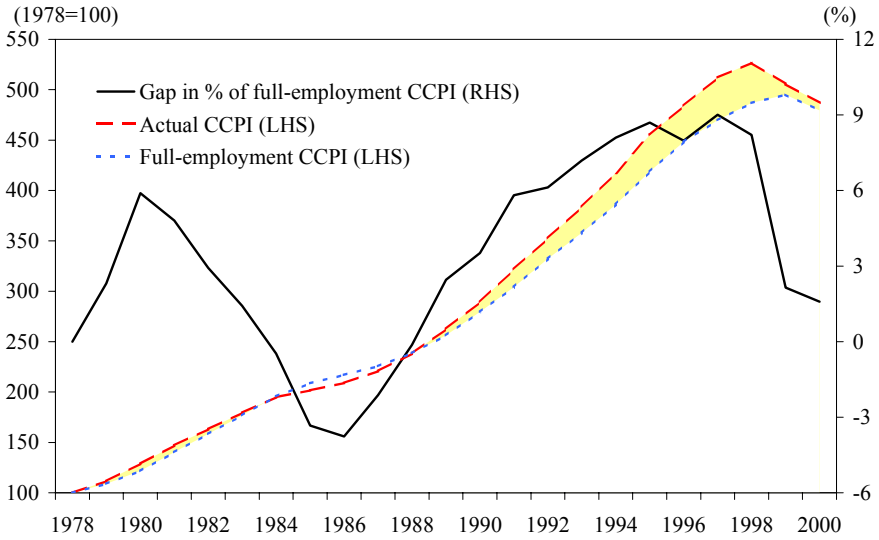
pushes inflation up by ¼ percentage point in the short run, with a full pass-though effect seen in the long run. It appears that the nominal effective exchange rate, which has appreciated by 25% since the adoption of the currency board arrangement in 1983, has served as an effective nominal anchor for inflation.

As shown in the last two columns of Table 4, regressions using output gaps estimated from the HP-filter and Kalman-filter yield similar results to those of the production function approach. In particular, the hypothesis of a full pass-through of import price—sum of the coefficient of the lagged inflation term and the coefficient of the import price equals one—is supported by the statistical tests in all cases.

b. Implications for the Recent Deflation Process

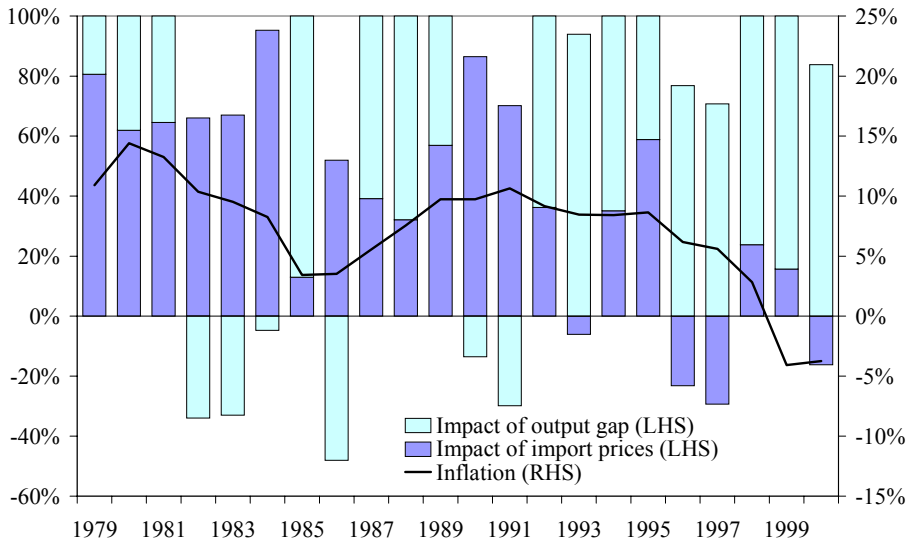
To assess the effect of output gap on inflation, we calculate a measure of "full-employment" price by simulating the inflation equation in the absence of output gaps. The simulated price index and the actual CPI diverged during 1990-1997, reflecting the effect of the prolonged large output gaps of that period. The divergence reached a high of 9 percent by 1997 (Chart 4). Nevertheless, prices declined sharply during 1998-2000, helped by downward flexibility in costs and prices, and the two indices have virtually converged.

Chart 4. Actual and a Measure of Full-employment Price Index



Finally, we calculate the relative impact of output gap and import price on inflation. The results indicate that changes in the import price had a large impact on inflation through 1983 (Chart 5), reflecting the depreciation of Hong Kong dollar prior to the establishment of the linked exchange rate system. In recent years the impact of output gap overwhelmingly dominated that of import price, suggesting that the recent deflation process was mainly a cyclical phenomenon, rather than changes in the world price of imports or the effective nominal exchange rate.

Chart 5. Impact of Output Gap and Import Prices on Inflation



VII. DISCUSSION OF MAJOR FINDINGS AND CONCLUDING REMARKS

This paper provides an assessment of Hong Kong's potential growth and output gap by estimating a Cobb-Douglas production function over the period of 1977-2000. Our results suggest that potential growth has moderated since the Asian financial crisis, but is still above the average of the G-7 countries. The negative output gap, which emerged in 1998-99, virtually vanished following a strong recovery in 2000. However, a negative output gap is likely to re-emerge in 2001 in view of the growth performance so far this year.

The exercise of decomposing growth sources finds that capital has the largest contribution to growth, while labour and TFP also play an important role. In particular, TFP has made larger contributions to growth than in other Asian economies. The contribution of TFP has moderated somewhat as the economy was maturing—an experience also shared by some industry countries.

We have also studied inflation dynamics in relation to the output gap and domestic price of imports by estimating an aggregate supply equation. The results suggest that output gap has a significant impact on inflation both in the short run and in the long run; a change in the import price has a significant contemporaneous effect on inflation, and is fully passed through to domestic price over the long run; and the ongoing deflation process is mainly a cyclical phenomenon. However, deflation is likely to continue in the immediate future due to possible re-emergence of a negative output gap in 2001 and the long-run effect of the negative gaps of 1998-2000.

Annex A. Econometric Estimation of the Production Function

We use econometric approach to directly estimate the production function. As the data on real GDP, real capital stock, and employment are non-stationary, as suggested by the unit root tests,[7] we estimate the production function using co-integration techniques that are particularly appropriate for uncovering long-run relationship between variables.

Equation (1) can be rewritten as

$$Log(Y_t) = Log(A) + \alpha Log(K_t) + \beta Log(L_t) \qquad \text{(A1)}$$

The co-integration method involves estimating a long-run linear relationship between the logarithms of output on the one hand and capital, labour, and technology progress on the other as expressed in equation (A1). The hypothesis of constant returns to scale ($\alpha + \beta = 1$), as opposed to increasing returns to scale ($\alpha + \beta > 1$) or decreasing returns to scale ($\alpha + \beta < 1$), can be tested within the model.

The results from the estimation of equation (A1) using data over the period 1977-2000 are presented in Table A1. The first regression does not impose the assumption of constant returns to scale. As the hypothesis of constant returns to scale ($\alpha + \beta = 1$) cannot be rejected using standard tests, regression (2) imposes the assumption of constant returns to scale and yields an estimate of the share of capital of the same magnitude. Both the Trace test and Maximum Eigenvalue test suggest the existence of one co-integrating relationship between output, capital, and labour.

Following the procedure as explained in Section IV, potential growth is estimated to be about 4% for 2000, the same as the IMF *WEO* estimates. The point estimate of capital share is close to Young's (1995) estimate for Singapore (see Table 3). However, the estimate should be interpreted with caution in view of its sensitivity to the construction of data on capital stock, which depends on assumptions on, among other, capital depreciation and utilisation.

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[7] Neither the Augmented Dickey-Fuller test nor the Phillips-Perron test can reject the hypothesis of unit root for output, capital, or labour.

Table A1. Production Function—Regression Results

(Dependent Variable: Log(Y))

	Regressions	
	(1)	(2)
Variable		
A	0.68	0.41
α	0.61	0.61
	(11.2)	(17.4)
β	0.33	0.39
	(1.65)	(17.4)
Summary statistics		
Trace Statistics	54.1 [1]	26.5 [1]
Max-Eigenvalue Statistics	26.7 [2]	23.0 [3]

[1] Trace test indicates one co-integrating equation at the 1 percent significant level.

[2] Max-eigenvalue test indicates 1 co-integrating equation at the 5 percent significance level.

[3] Max-eigenvalue test indicates 1 co-integrating equation at the 1 percent significance level.

Note : t-statistics in parentheses.

Annex B. Construction of Capital Stock

Since official data on capital stocks are not available, the perpetual inventory method is used to construct the time series. The formula is given by equation (B1), where I and δ represent gross investment and rate of depreciation, respectively. The depreciation rate was assumed to be 7% for machinery and equipment and 3% for structure.[8]

$$K_t = I_t + (1-\delta)K_{t-1} \qquad \text{(B1)}$$

The initial estimate of capital (K_0) is based on the assumption that capital-to-output ratio was at a steady state, at which the growth in capital equals the growth in output.

$$dK_t/K_t = dY_t/Y_t. \qquad \text{(B2)}$$

Equation (B1) can be rewritten as $dK_t/K_t = I_t/K_t - \delta$. Substituting into (B2) yields,

$$\frac{K}{Y}\left(\frac{\Delta Y}{Y} + \delta\right) = \frac{I}{Y} \qquad \text{(B3)}$$

The average investment-output ratio and output growth during 1966-1970 is used to approximate the steady state. The average real output in the same 5-year period was taken as an estimate of initial output (Y_0) in 1968. The steady-state capital-to-output ratio is multiplied by Y_0 to generate an initial estimate of capital stock (K_0). A time series for capital stock is then generated through equation (B1).

[8] These assumptions are in line with the rates of depreciation estimated by the US Bureau of Economic Analysis and Australian Bureau of Statistics. The series could have been refined if data on capital consumption allowances for Hong Kong had been available.

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