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LONG-TERM AND SHORT-TERM DETERMINANTS OF PROPERTY PRICES IN HONG KONG

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Abstract

Property prices in Hong Kong increased markedly in late 2007 and early 2008, raising concerns about the risk of overheating in the property market. In this paper, we use co-integration analysis to analyze the short- and long-run determinants of property prices in Hong Kong. We find that the long-run determinants include GDP per capita, real interest rate, land supply, and the residential investment deflator, which reflects the impact of inflation and real construction cost. In the short-run, property price is also affected by equity price. Based on this framework, we assess the market conditions in early 2008. We also do graphical and clustering analyses of six property market indicators to supplement the co-integration analysis.

JEL Classification Numbers: R31
Keywords: Property price, overheating, co-integration, clustering analysis

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EXECUTIVE SUMMARY

- *Property prices in Hong Kong increased markedly in late 2007 and early 2008, raising concerns about the risk of overheating in the property market. Negative real interest rates were often cited as the main reason for the upsurge in property prices, and there were worries that they encouraged speculative activities. Our empirical analysis, however, suggests that the rise in property prices was largely underpinned by stronger economic fundamentals, and there were no major signs of overheating in the property market.*

- *Using reduced-form demand-supply equations, co-integration analysis suggests that the long-run equilibrium real property price in Hong Kong is determined by real per-capita income, real interest rate, land supply and the residential investment deflator, which reflects the impact of inflation and real construction cost. In the short-run, property price is also affected by equity prices.*

- *A breakdown by the contribution of different determinants shows that the rebound in the real property price from late 2003 to early 2008 was supported by steady growth in household income and increases residential investment deflator. Negative real interest rates were found to have played a relatively small role in explaining the upsurge in real property prices since 2005.*

- *The actual real property price is found to be somewhat above its estimated long-run equilibrium value in late 2007, but the deviation from the long-run equilibrium value is relatively small compared to previous episodes of property market booms. The short-run model suggests that the overshooting in house prices could be due to spill-over effect from the stock market rally in 2007. As domestic equity prices have declined considerably since late 2007 and house prices have levelled off recently, the risk of overheating in the property market will likely diminish for the remainder of 2008.*

- *Qualitative analysis of six property market indicators using a graphical framework suggests few signs of overheating pressure in the property market in the first half of 2008. Statistical analysis of the six indicators using the clustering method also does not point to an overheated property market.*

I. INTRODUCTION

House prices in Hong Kong increased rapidly from late 2007 to early 2008 before stabilising in recent periods. While robust growth in household income and lower borrowing costs after successive interest rate cuts by the US Fed seemed to have provided some fundamental support to the rise in property price, the sharp pace of price appreciation within a short period of time raised concerns about the risk of overshooting and the formation of an asset bubble. Hong Kong is now in the situation of negative real interest rates, i.e. nominal interest rates fall below the inflation rate, which is often cited as a catalyst for speculative activities. Moreover, property prices in the luxury segment have breached the record high in mid-1997, and the number of confirmor transactions, an indicator of speculative activities in the property market, rose during the first quarter of 2008.

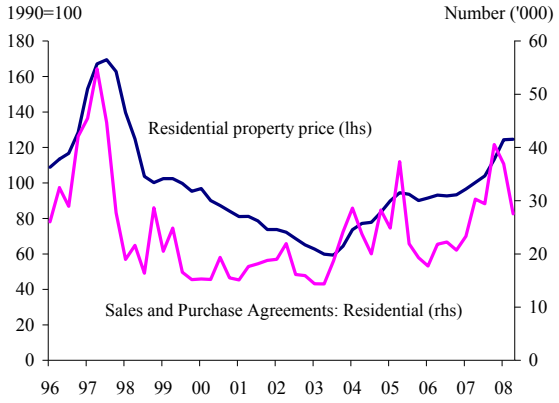
Has the recent increase in property prices been attributable to improved economic fundamentals or have prices already overshot on the upside? Answering this question requires an estimate of the long-run equilibrium property price implied by economic fundamentals. This paper uses co-integration analysis to estimate reduced-form demand-supply equations in order to understand the short- and long-run determinants of property prices in Hong Kong. We also analyses six property market indicators using a graphical framework and a statistical technique called clustering analysis to assess the risk of overheating in the property market.

This paper is organized as follows. Section II reviews the recent property market developments in Hong Kong and identifies key fundamental determinants of property prices. Section III estimates the long-run equilibrium residential property price, assesses the extent of deviation between the actual and the long-run equilibrium property prices, and analyses the short-run dynamics of property prices. Section IV analyses six property market indicators using a graphical framework and the clustering method to gauge the risk of overheating in the property markets. Section V concludes.

II. FUNDAMENTAL DETERMINANTS OF PROPERTY PRICES IN HONG KONG

Residential property prices in Hong Kong rose notably in the second half of 2007 and in Q1 2008 before levelling off recently. On a year-on-year comparison, growth in average house price accelerated from 8% in Q2 2007 to nearly 30% in Q1 2008. Meanwhile, the transaction volume started to decline since early 2008 after notably increases over the preceding two years, contracting by 32% in the first half of 2008 from the end of 2007 (Chart 1).

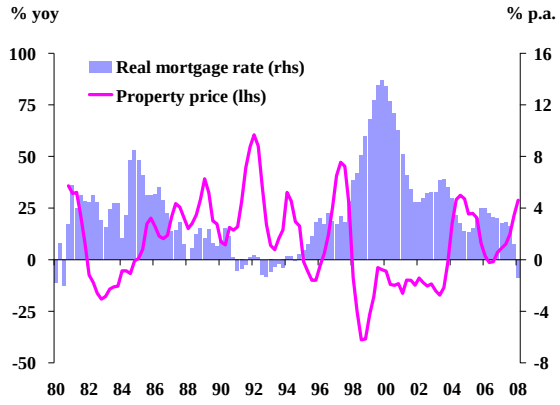
Chart 1: Residential property price index and transaction volume



Sources: R&VD and Land Registry.

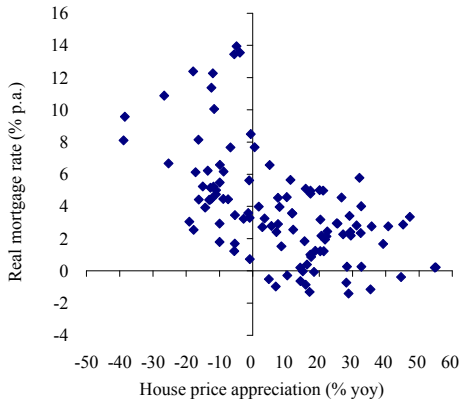
The annual rate of CPI inflation rose to 5-6%, which was higher than the average mortgage interest rate of around 3% in the first half of 2008. Such a situation of negative real interest rate was widely quoted as the catalyst of the steep rise in residential property prices since late 2007. Historical data show that house price appreciation accelerated when real mortgage rate turned negative in the early 1980s and 1990s. A similar pattern can be observed in the recent episode of negative mortgage rate (Chart 2). The scatter plot of real mortgage rate against the year-on-year house price appreciation suggests that there is a negative relationship between the two, as lower funding costs in real terms increase housing affordability (Chart 3).

Chart 2: Movements of real mortgage interest rate and house price appreciation



Sources: R&VD and staff estimates.

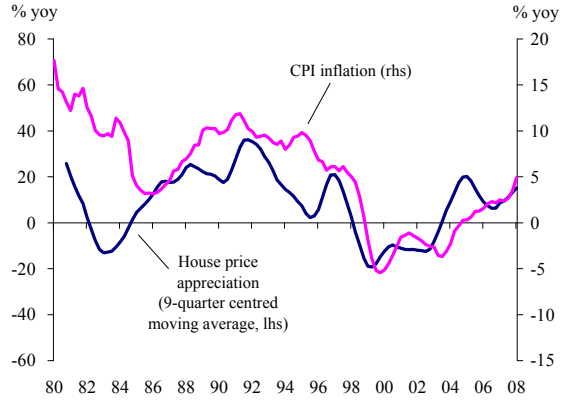
Chart 3: Real mortgage interest rate and house price appreciation (1980Q4-2008Q1)



Sources: R&VD and staff estimates.

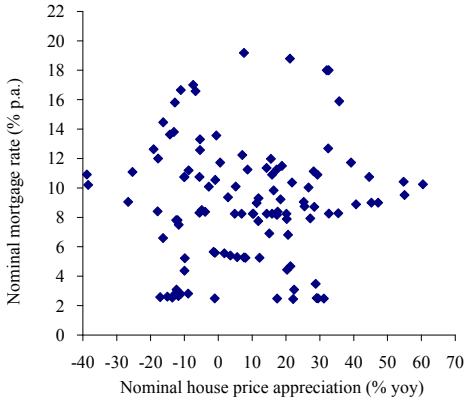
The inverse relationship between house price appreciation and real interest rates mainly reflect strong co-movement between the growth in property price and inflation rate (Chart 4). The strong co-movement remains intact even if property price is measured in real terms (i.e. deflated by the composite CPI excluding the rental component). There is no clear evidence of a negative relationship between house price appreciation and nominal interest rate (Chart 5).

Chart 4: Mortgage rate, CPI inflation and house price appreciation



Sources: C&SD, R&VD and staff estimates.

Chart 5: Nominal mortgage rates and house price appreciation (1980Q4-2008Q1)



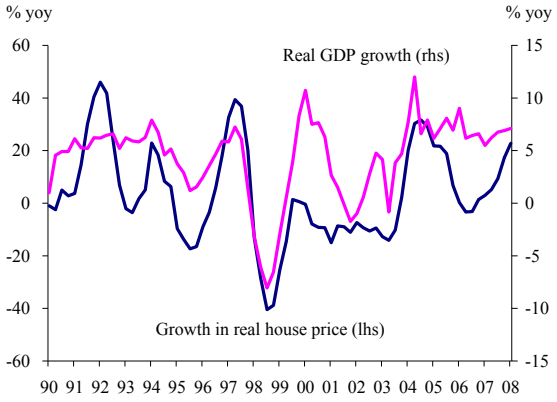
Sources: R&VD and staff estimates.

The strong co-movement between property price and inflation shows that the latter could be a major determinant of property prices. In general, there are three channels through which inflation can affect property price. First, given a certain level of nominal interest rate, rising expected inflation will reduce the borrowing cost in real terms, boosting the demand from end-users and investors (the funding cost channel, as proxied by the real interest rate above).

Secondly, in an environment of rising inflationary expectations, there are usually concerns about the loss of the purchasing power of money, and investment in fixed assets like real estate is regarded as a hedge against inflation (the inflation hedging channel). Thirdly, under an inflationary environment, rising construction costs would lead property developers to set higher prices for their newly completed residential units in the primary market, which may drive up the overall property price (the cost channel).

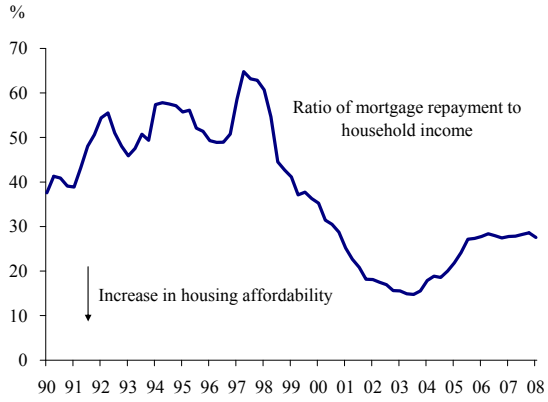
Apart from real interest rate and inflation, house prices appear to have strong co-movements with income growth as well (Chart 6). The continued solid growth in labour income over the past few years enhanced the housing affordability of home-buyers. The income-gearing ratio, which is the ratio of mortgage repayment to household income, remained largely stable over the past few years despite the rapid rise in house prices, in part reflecting strong income growth (Chart 7).

Chart 6: Property price and GDP growth



Sources: C&SD and R&VD.

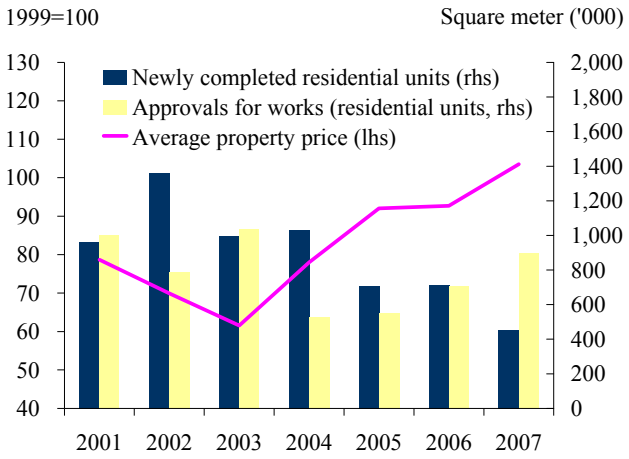
Chart 7: Housing affordability (Income-gearing ratio)



Source: Staff estimates.

Reduced land supply is also widely believed to be an important driver of rises in property price in recent years. Owing to the slowdown in land supply over the past couple of years, newly completed residential properties (measured in terms of floor area built) contracted by 37% in 2007, following tepid growth of 1% in 2006 (Chart 8). As higher prices and growing demand in the property market made building houses more profitable, property developers have sped up their property development and approvals for commencement of building residential units increased strongly by 27% in 2007. However, supply of residential property is expected to remain tight in the near future, given the 2-3 year time lag between the commencement and completion of residential properties.

Chart 8: Property price and supply of residential properties



Sources: R&VD and CEIC.

III. EMPIRICAL ANALYSIS ON PROPERTY PRICE MOVEMENTS IN HONG KONG

To understand the key driving forces behind the recent house price appreciation, econometric analysis is conducted to estimate the contribution of different determinants of real property price movements in the long run and short run. The analysis serves two purposes. First, the estimation of the long-run equilibrium property price can be used to gauge the deviation between actual and long-run equilibrium property prices, which is useful for assessing the risk of overheating in the housing market. Secondly, by estimating the short-run property price equation, the factors leading to the deviation of the actual property price from its long-run equilibrium value can be identified, which is useful for understanding the causes of such deviation in the short run.

Long-run determinants of real property prices

There are several methods to estimate the long-run equilibrium residential property prices. Peng (2002) showed that the fundamental property value can be estimated by the present value of the expected future rental income. It also showed that movements in property prices can be characterised by a speculative bubble model, in which the observed property price is composed of two components capturing the fair value of the property and the building and bursting of an asset price bubble. Recently, structural models have been used to estimate

the equilibrium property price jointly determined by the forces of demand and supply in the studies by Leung and Liu (2005) and Glindro et al (2008).

In this paper, we use a reduced-form demand-supply model to estimate the long-run equilibrium property price in Hong Kong. The starting point is to identify the fundamental determinants of property price on the demand and supply sides. The long-run demand function can be represented by equation (1).

$$h_t^d = f(p_t^d, y_t, r_t) \quad (1)$$

The dependent variable h_t^d is the demand for private housing stock, which is determined by factors including the real property price (p_t^d), real GDP per capita (y_t), and the real best lending rate (r_t) defined as the nominal best lending rate less CPI inflation rate. The sign of the coefficient on p_t^d is expected to be negative, representing a downward sloping demand curve. Given a certain level of property price, higher household income and lower real interest rate improve housing affordability, which will increase the demand for property. Thus, the expected sign of coefficient on y_t is positive and that on r_t is negative.

On the supply side, the long-term supply function can be represented by equation (2).

$$h_t^s = f(p_t^s, x_t, L_{t-2}) \quad (2)$$

The dependent variable h_t^s is the supply of private housing stock, which is determined by real property price (p_t^s), the deflator of private residential investment excluding the property developer's margin (x_t) and the land supply with two-period lag (L_{t-2}). The sign of coefficient on p_t^s is expected to be positive, representing an upward sloping supply curve. The private residential investment deflator is affected by general inflation and real cost pressure in the construction sector. Given stable property price, higher cost pressure on the supply side will eat out profit for property development, so the sign of coefficient on x_t is expected to be negative. The sign of the coefficient on the land supply variable L_{t-2} is expected to be positive, as more land supplied by the government for residential property development will increase the housing stock in future. For an inverse supply curve in which price is the

dependent variable, the sign of coefficient on the residential investment deflator is positive, as higher cost pressure on the supply side will be ultimately passed through to property prices in the long run, while the sign of the coefficient on land supply is negative, as increase in land supply will restrain property prices.

The long-run equilibrium condition requires $p_t^d = p_t^s = p_t^*$ *and* $h_t^d = h_t^s$, suggesting that at the equilibrium price p_t^*, there is no excess demand or excess supply in the property market. Combining equations (1) and (2) yields the long-run equilibrium function of the property price, which can be represented by equation (3).

$$p_t^* = f(y_t, r_t, x_t, L_{t-2}) \tag{3}$$

While the long-run equilibrium property price p_t^* is not observable, it can be estimated by regressing the actual property price on its fundamental determinants. Assuming a linear relationship exists between the equilibrium property price and its determinants in the long run, equation (3) can be written as equation (4).

$$p_t^* = c_0 + c_1 y_t + c_2 r_t + c_3 x_t + c_4 L_{t-2} \tag{4}$$

The existence of a co-integrating vector among p_t, y_t, r_t, x_t and L_{t-2}, is consistent with there being a theoretical long-run equilibrium relationship between real property price and its fundamental determinants exists. Residual-based test for co-integration based on the Engle-Granger methodology suggests that a long-run co-integrating relationship does exist. A simple and efficient way to estimate such a long-tem relationship, i.e. a co-integrating vector of [1, c1, c2, c3, c4] is to run a dynamic OLS (ordinary least square) regression as represented by equation (5).[2]

$$p_t = p_t^* + \sum_{j=-k}^{k} \Delta y_{t-j} + \sum_{j=-k}^{k} \Delta r_{t-j} + \sum_{j=-k}^{k} \Delta x_{t-j} + \sum_{j=-k}^{k} \Delta L_{t-j} + \varepsilon_t \tag{5}$$

[2] Dynamic ordinary least square (OLS) can eliminate problems of simultaneity in the estimation of coefficients and serial correlations in the residuals. One difficulty associated with the use of dynamic OLS is to determine the number of lags and leads for the explanatory variables, which are chosen to be three based on test statistics.

Based on a sample of quarterly data from 1986 to 2007, it is found that there is a long-run equilibrium (co-integrating) relationship among real property price, real GDP per capita, real interest rate, land supply and the price deflator of private residential investment. The estimated results of the long-run equilibrium model of property price are summarised in Table 1.

Table 1: Long-run determinants of real property prices

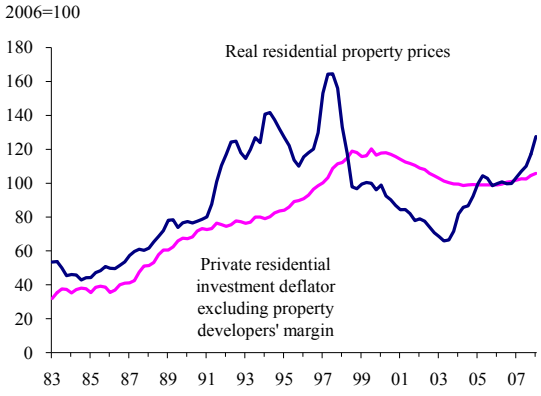
Dependent variable: Real residential property price	Beta	Standard error	t-ratio
Constant	189.566	60.835	3.116
Real GDP per capita	0.714	0.382	1.871
Real interest rate	-3.087	1.322	-2.335
Two-quarter lag of land supply	-27.138	8.904	-3.048
Residential investment deflator	0.023	0.003	8.751
Adjusted R^2: 0.856			

Note: The relationship is estimated by dynamic ordinary least square method with heteroskedasticity-autocorrelation consistent (HAC) standard errors. The leads and lags of the dynamic terms are not shown in the table.

Source: Staff estimates.

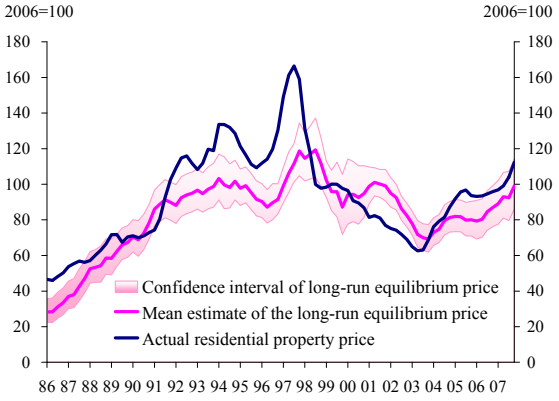
The estimated coefficients are statistically significant at the 5% level and are of the correct signs. The price deflator of private residential investment, which by definition is affected by the general inflation and real construction cost, is used to capture the effect of inflation through channels other than the real interest rate (i.e. the inflation hedging channel and the cost channel) as well as the impact of real construction cost. The high statistical significance of the private residential investment deflator suggests that inflation can affect real property prices not only through the real interest rate (the funding cost channel), but also through the inflation hedging and the cost channels. A graphical comparison shows that there are relatively strong co-movements between the real property price and the private residential investment deflator (Chart 9).

Chart 9: Residential property price and private residential investment deflator



Sources: C&SD, R&VD and staff estimates.

Chart 10: Actual and equilibrium real property prices

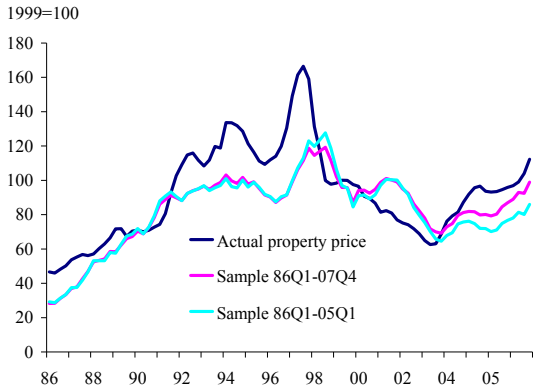


Sources: C&SD, R&VD and staff estimates.

The estimated long-run co-integrating relationship can be used to estimate the long-run equilibrium property price in Hong Kong. Chart 10 shows the actual and estimated equilibrium property prices in real terms since the 1990s. Real property prices are found to be mostly above the equilibrium values in the 1990s, with peak over-valuation of 50-60% in 1997. This finding is consistent with the previous studies by Peng (2002) and Leung and Liu (2005). The substantial overvaluation suggests that there was a property bubble in 1997. The bubble subsequently burst and real property prices dropped for seven consecutive years, leading to substantial under-valuation of about 20% in 2001-2003. Thereafter, both the actual and equilibrium property prices started to recover alongside improving economic fundamentals. Real property price is estimated to be somewhat above its long-run equilibrium in Q1 2008, but the deviation from long-run equilibrium value is relatively small compared to previous episodes of property market booms. Improving economic fundamentals, such as steady growth in household income, low real interest rates, limited supply of land, rising inflation and higher construction cost have increased the long run equilibrium value of residential property in real terms since 2003, underpinning the current upsurge in the actual property price.

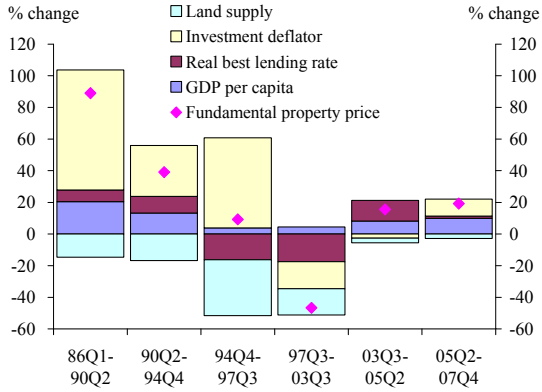
To test the robustness of the estimates obtained from the long-run equilibrium model, an out-of-sample forecast of the fundamental property price in real terms is conducted using a smaller sample. This is done by excluding the observations in 2006 and 2007. Chart 11 shows that after using a smaller sample, the estimated equilibrium real property price will be lower than that estimated from the full sample, but both series show a similar rising trend starting from 2005. Overall, the estimated long-run equilibrium real property price is not sensitive to changes in the sampling period for estimation.

Chart 11: Out-of-sample forecast of the long-run equilibrium real property price



Sources: R&VD and staff estimates.

Chart 12: Contribution to changes in the long-run equilibrium real property price



Source: Staff estimates.

A breakdown by the contribution of different fundamental determinants of real property price shows that the private residential investment deflator explained most of the movements in the long-run equilibrium real property price in the late 1980s and the early 1990s (Chart 12). The sharp fall in the fundamental value of residential property in the aftermath of the Asian financial crisis was attributed to the decline in the residential investment deflator, increases in the land supply and higher real interest rates as CPI inflation turned negative. The rebound in the fundamental real property price from the second half of 2003 to Q1 2008 was underpinned by stronger household income and lower real interest rates, while rising inflation and real construction cost (jointly measured by the residential investment deflator) has also played an important role. The contribution of negative real interest rate is found to be small during the episode of upsurge in long-run equilibrium real property prices since 2005.

Short run adjustment equation for real property prices

Short-run factors may cause property prices to deviate from its long-run equilibrium value. These short-run factors may include changes in the expectations on the future property price movements. People may form their expectations on future property price movements based on the past trend. The property market also tends to move in the same direction as the equity market with some lags, as the latter contains information on business sentiments and market expectation on economic outlook. Increase in wealth from rising equity prices may stimulate demand for residential properties through the so-called wealth effect. In fact, the rapid rise in equity prices in late 2007 on the announcement of the through-train scheme by Mainland authorities reportedly stimulated property

market transactions. To capture the effects of these factors on real property prices, an error correction model is used to explain the short-run dynamics in the property market, as specified in equation (6).

$$\Delta p_t = \alpha \Pi_{t-1} + \theta \Delta p_{t-1} + \beta_1 \Delta y_t + \beta_2 \Delta r_t + \beta_3 \Delta x_t + \beta_4 \Delta s_t \quad (6)$$

Equation (6) hypothesizes that changes in actual real property price is dependent on changes in its long-run fundamental determinants including real GDP per capita (y_t), real interest rate (r_t), residential investment deflator (x_t) and other short-run factors including changes in the stock market index (Δs_t) and past property prices (Δp_{t-1}).[3] Following the interpretations of Leung and Liu (2005) and Peng (2002), change in property prices in the past period captures the effect of backward-looking expectations on the change in current property prices. If the actual real property price deviates from its long-run equilibrium value, there will be market forces closing the gap between the two over time, which is captured by the error-correction term Π_{t-1}.[4] The estimated results of the short-run adjustment equation are presented in Table 2.

[3] As the change in property price is mainly demand-driven in the short run, land supply is not included and is not statistically significant in equation (6).

[4] The error-correction term is estimated as the deviation of the actual property price from the long-run equilibrium value p_t^* in equation (5) based on the estimation result in Table 1.

Table 2: Estimated results of the short-run adjustment equation of real property prices

Dependent variable: Real residential property price	Beta	Standard error	t-ratio
Error-correction term	-0.102	0.025	-4.081
Lag of real house price	0.588	0.065	9.057
Real GDP per capita	0.717	0.325	2.208
Real interest rate	-0.857	0.360	-2.378
Residential investment deflator	0.010	0.003	3.806
Real Hang Seng Index	0.188	0.038	4.899
Adjusted R^2: 0.630			

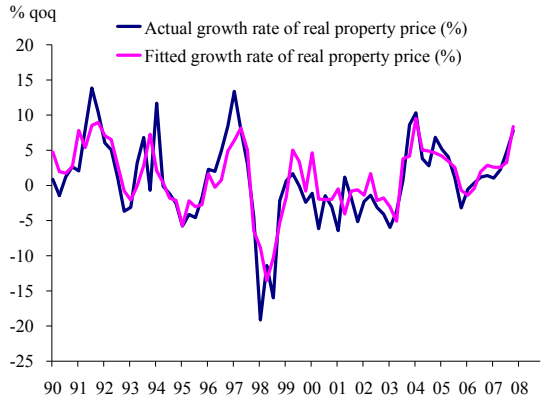
Note: All variables are either in first difference or log-difference, except for the error-correction term. Heteroskedasticity-autocorrelation consistent (HAC) standard errors are used.

Source: Staff estimates.

All the explanatory variables are statistically significant at the 5% level and of the correct signs. The coefficient on the error-correction term suggests that about one-tenth of the deviation between the actual and long-run equilibrium property prices will be corrected within one quarter. The high statistical significance of the coefficients on the one-quarter lag of change in real property price and on the current quarter change in the equity price index suggests that they are important in explaining the change in actual real property price in the short run. Chart 13 compares the actual and estimated quarter-on-quarter growth rate of real property prices. The short-run dynamic model seems to fit the data well particularly for the more recent periods.

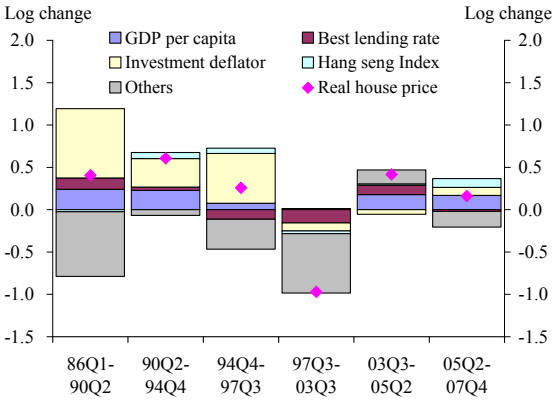
Combining the effects of the long-run and short-run factors on the real property price, a breakdown of contribution shows that the residential investment deflator explained most of the property price movements in the late 1980s and the early 1990s, while real interest rate was a key factor leading to the property price swings during 1997-2003 and 2003-2005 in part reflecting the fluctuations of inflation in these periods. The upsurge in residential property prices between 2005 and 2007 was largely attributable to the stock market rally and strong income growth, while the decline in real interest rates was not the main driver of the house price appreciation (Chart 14).

Chart 13: Actual and estimated growth rates of real property price



Sources: R&VD and staff estimates.

Chart 14: Contribution to changes in actual real property price by factor



Source: Staff estimates.

Empirical findings suggest that while residential property price might be somewhat above its long-run equilibrium as of Q1 2008, the risk of overheating remains relatively small given that the recent house price appreciation has been supported by improved fundamentals such as stronger income growth. The estimates from the short-run dynamic model show that the steep rise in house price over its long-run equilibrium value could be due to spill-over effect from the stock market rally. As domestic equity prices have declined considerably since the start of 2008 and house prices have levelled off recently, the extent of deviation of the actual property price from the long-run equilibrium value is expected to narrow somewhat for the remainder of 2008.

Our analysis suggests that inflation is a key underlying factor driving house price movements through its impact on construction cost and expectations on future property price movements. While negative interest rate has been widely quoted as the main cause of the recent upsurge in property prices, empirical findings show that it is not the dominant driving force. Past developments show that domestic interest rates and inflation could be very volatile, thus both home-buyers and real estate investors should be cautious on the possibility of a reversal of the current trend of interest rates or inflation on the property market.

IV. GRAPHICAL FRAMEWORK AND CLUSTERING ANALYSIS FOR ASSESSING THE RISK OF OVERHEATING IN THE PROPERTY MARKET

While the estimation of long-run equilibrium property price is useful for assessing the extent of deviation of the observed property price from its long-run equilibrium, the quarterly estimates are available with considerable time lags. For more timely monitoring of symptoms of overheating in the property market, the HKMA also uses a graphical framework consisting of six indicators. The six indicators are real property price, transaction volume, real new mortgages, the number of confirmor transactions, the income gearing ratio, and the buy-rent gap. The definition and interpretation of the six indicators are summarised in Table 3. Basically, what the graphical framework does is to compare the values of the indicators with their values recorded in the overheating period of 1997. If the current values of the indicators are close to the levels in the 1997, the risk of overheating in the property market is higher.[5]

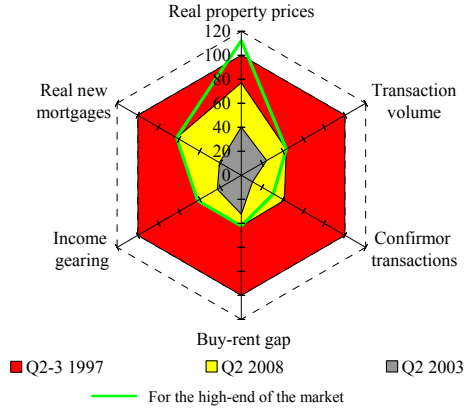
[5] For details, please refer to Chan, Peng and Fan (2005).

Table 3: Indicators Used in the Graphical Framework

Indicator	Definition	Interpretation
Real property price	● The price index for private domestic premise adjusted by the rateable value of the residential property and deflated by the Composite CPI.	● It is the most direct and simple indicator of the demand and supply conditions in the property market.
Transaction volume	● Transaction volume is measured by the ratio of the number of sale and purchase agreements to total private housing stock, i.e. the turnover rate.	● It indicates the buoyancy of activity in the property market.
Real new mortgages	● New mortgages refer to the amount of new loans for private residential properties provided by authorised institutions, deflated by the Composite CPI.	● Past experiences show that bank credit can amplify property price swings.
Confirmor transactions	● Confirmor transactions are those in which a buyer re-sells the residential unit to a sub-purchaser before the legal completion of the original sale. It is expressed as a percentage share of total transactions.	● It is an indicator of the extent of speculative activity in the property market.
Income-gearing ratio	● The ratio of mortgage repayment to household income.	● It is a measure of housing affordability of the private housing owners.
Buy-rent gap	● The ratio of the cost of purchasing and maintaining a flat to the rental cost.	● It compares the cost of owning a flat relative to renting a flat.

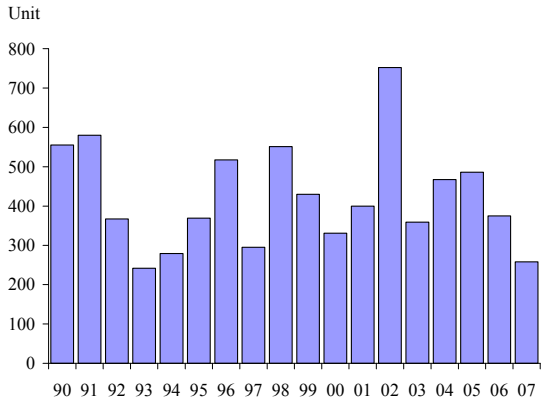
Comparing the readings of the six indicators with their levels in previous boom-and-bust cycles in the property market reveals the healthiness of the current market condition. The latest figures do not point to an overheated property market in 2008 Q2 (Chart 15). Specifically, average house prices were still notably below the peak in real terms. The proportion of confirmor transactions to total transactions, which is an indicator of speculative activity, remained small at 3-4% comparing with 6-8% in mid-1997. While the prices of luxury flats increased more rapidly and breached the record high in 1997, it was largely driven by growing demand for and tight supply of large flats in the property market (Chart 16).

Chart 15: Graphical framework with key property market indicators



Sources: R&VD, Centaline and staff estimates.

Chart 16: New completion of large-size (over 160m^2) residential units



Sources: R&VD and Centaline.

The graphical analysis above is qualitative and judgemental. Sometimes the judgement is difficult because the distinction between a healthy expansion and an overheating situation may not be obvious. It is desirable if the six indicators can be jointly analysed using an objective statistical technique that can distinguish different types of market conditions. Market conditions can be analysed along two dimensions: (1) whether the property market is rising, stable or decreasing; and (2) whether the property market is over-valued, fairly-valued, and undervalued. The two dimensions together give rise to nine possible market scenarios, with the "rising and over-valued property price" scenario representing an overheating situation.

The nine market scenarios can be distinguished by a statistical technique called clustering analysis. Clustering analysis groups data with similar characteristics together by minimising the distance between the group mean and its members and maximising the distance of the group means between two adjacent clusters.[6] Based on a sample of monthly data from January 1996 to March 2008, nine different groups are classified based on the data characteristics of the six indicators used in the graphical framework.[7] Table 4 summarises the key statistics of the nine groups.

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[6] The methodology of clustering analysis and its applications are summarised in Annex A.

[7] Of the six indicators used in the clustering analysis, the measures of real property price and real new mortgages have been revised from those previously used in the graphical framework. Instead of using the level of real property price, the three-month-on-three-month change in real property price is used to capture the impact of house price appreciation (or depreciation) on market activity. On the other hand, real new mortgages are scaled by the outstanding amount of mortgage loans to control for the size effect. Using the new measures of real property price and real new mortgages did not change the results of clustering analysis significantly if we adopt the same definitions used in the graphical framework.

Table 4: Summary Statistics of Individual Cluster/Group

Group	Obs.	Proportion	Group Mean					
			Real house price	Transaction volume	Mortgage loans	Confirmor transaction	Income gearing ratio	Buy-rent gap
A	5	3%	8.7	1.9	7.9	7.5	63.2	245.1
B	3	2%	14.7	1.6	6.2	4.7	56.0	222.7
C	6	4%	-4.7	1.0	3.9	2.5	60.6	256.0
D	30	20%	1.7	0.9	3.5	1.5	42.5	192.5
E	4	3%	-13.2	0.7	2.6	1.3	60.7	267.7
F	17	12%	4.0	0.8	2.6	2.9	23.5	116.8
G	5	3%	-14.9	0.7	2.1	0.7	46.2	232.9
H	39	27%	-0.3	0.7	2.1	1.4	28.1	147.7
I	38	26%	0.8	0.6	1.6	1.7	17.1	89.1

Notes: Real house price = House price appreciation, three-month-on-three-month, %.
Transaction volume = Transaction volume as a share of housing stock, %.
Mortgage loans = New mortgage loans as a share of outstanding mortgage loans, %.
Confirmor transaction = Number of confirmor transactions as a share of total transactions, %.
Income gearing ratio = Monthly mortgage repayment as a share of household income, %.
Buy-rent gap = Ratio of the cost of buying a flat to rental cost, %.

Source: Staff estimates.

In general, higher readings of the indicators suggest increased risk of overheating in the property market. A cursory look at the data suggests that group I probably represents a sluggish property market situation where the readings of four out of six indicators are the smallest (except for real house price and confirmor transaction). In contrast, the mean of four out of the six indicators in group A are the highest (except for real house price and the buy-rent gap), suggesting an overstretched property market. To visualise the distribution of observations in each group across the whole sample period, we calculate the cluster score of each group, defined as the ratio of the difference between group mean and the whole sample to the standard deviation of the whole sample, for each of the six indicators. The cluster scores of each indicators are then summed together to arrive at a total score for each group. Table 5 shows that the total scores arranged in descending order, with group 1 yielding the highest score of 13.4, versus the lowest score of -3.3 for group 9.

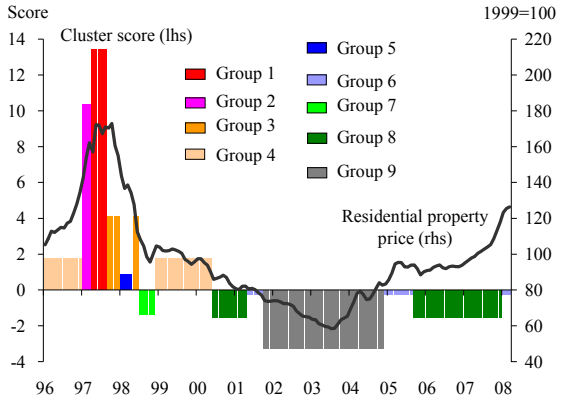
Table 5: Standard Scores of Individual Cluster/Group

Group	Real house price	Transaction volume	Mortgage loans	Confirmor transaction	Income gearing ratio	Buy-rent gap	Total
1	1.3	2.8	2.9	3.1	1.9	1.5	**13.4**
2	2.1	2.2	2.0	1.5	1.4	1.1	**10.3**
3	-0.7	0.5	0.7	0.3	1.7	1.7	**4.1**
4	0.2	0.2	0.4	-0.3	0.6	0.6	**1.7**
5	-1.9	-0.3	-0.1	-0.4	1.7	1.9	**0.8**
6	0.6	0.0	-0.1	0.5	-0.6	-0.6	**-0.2**
7	-2.2	-0.1	-0.4	-0.8	0.8	1.3	**-1.4**
8	0.0	-0.3	-0.4	-0.3	-0.3	-0.1	**-1.6**
9	0.1	-0.4	-0.6	-0.2	-1.0	-1.1	**-3.3**

Source: Staff estimates.

Plotting the total cluster scores against the residential property price index suggests a relatively strong co-movement between the two (Chart 17). It can be seen that groups 1 and 2 capture the episode of property price bubble during the first half of 1997. Groups 3 and 5 capture the subsequent burst of the property bubble. Groups 4, 6, 7 and 8 represent stable market conditions, while group 9 represents sluggish and undervalued property market conditions. Plotting the total cluster scores against the deviation from the long-run equilibrium value estimated from the co-integration model also shows a relatively strong positive correlation between these two measures, suggesting that assessments based on the two methods should yield similar results.

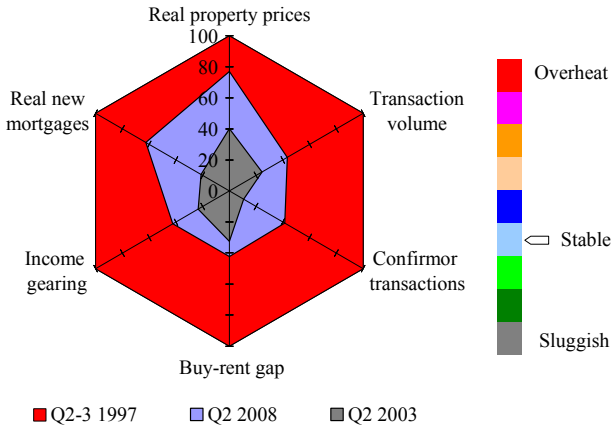
Chart 17: Cluster score and residential property price



Source: Staff estimates.

Based on the groups classified using the clustering method and the readings of the six indicators, the monthly observations in the second quarter of 2008 are classified as members of group 6. This does not suggest an overheated property market, which is consistent with our qualitative assessment of the property market indicators using the graphical framework (Chart 18).

Chart 18: Cluster score and graphical framework, 2008Q2



Source: Staff estimates.

V. CONCLUSIONS

This paper reviews the recent property market developments in Hong Kong and identifies the short-run and long-run determinants of residential property price. By comparing the observed property price with the estimated long-run equilibrium value, it is found that the extent of deviation has been relatively modest in recent years.

Qualitative analysis of six property market indicators using a graphical framework suggests that there were few signs of overheating pressure in the property market in the first half of 2008. Statistical analysis of the six property market indicators using the clustering method also suggests that property market conditions during the first half of 2008 were not unhealthy, which is consistent with our qualitative analysis using the graphical framework and the findings based on the long-run equilibrium model of property price.

Annex A

Methodology of Clustering Analysis

Clustering analysis is a multivariate method for classifying a complex set of data into a few groups or clusters. No assumptions are made regarding the group structure, and grouping is done on the basis of similarities or distances (dissimilarities). There are different methods for grouping data or variables using the clustering analysis.[8] The method adopted in this paper is known as the K-means method, which assigns each observation to the cluster with the nearest mean. The procedure of using this method for grouping data consists of three steps:

1. Partition the data set into K initial clusters.

2. Assign each observation to the cluster whose mean is the nearest. Recalculate the mean for the cluster receiving the new item and for the cluster losing the item.

3. Repeat the process until all observations are classified into different clusters.

In practice, the number of clusters (the value of K) has to be determined for preliminary grouping, and to be adjusted until a satisfactory result is obtained. The final assignment of observations to clusters will be, to some extent, dependent on the initial choice of the number of partitions or clusters. The following example illustrates how the K-mean method assigns different observations to clusters.[9]

Suppose there are two variables X and Y with four observations A, B, C and D. The data are shown in the following table.

	Variable	**Variable**
Observation	**X**	**Y**
A	5	3
B	-1	1
C	1	-2
D	-3	-2

[8] For an introduction to various methods used in clustering analysis, please refer to Johnson and Wichern (1992).

[9] The example is adopted from Chapter 12 of Johnson and Wichem (1992).

Suppose the initial number of cluster is set to two (K=2), and the data are arbitrarily partitioned into two groups, namely cluster(AB) and cluster(CD). The means of these two clusters are calculated and shown in the following table.

	Variable	**Variable**
Cluster mean	**X**	**Y**
(AB)	(5-1)/2 = 2	(3+1)/2 = 2
(CD)	(1-3)/2 = -1	(-2-2)/2 = -2

The next step is to compare the squared distance between observation A and the mean of cluster(AB) and cluster(CD) respectively.

Distance (A - cluster(AB))^2 = (5-2)^2 + (3-2)^2 = 10
Distance (A – cluster(CD))^2 = (5+1)^2 + (3+2)^2 = 61

As observation A is closer to the mean of cluster(AB), no reassignment is needed. Next, we calculate the squared distance between observation B and the mean of cluster(AB) and cluster(CD) respectively.

Distance (B - cluster(AB))^2 = (-1-2)^2 + (1-2)^2 = 10
Distance (B – cluster(CD))^2 = (-1+1)^2 + (1+2)^2 = 9

Since observation B is closer to the mean of cluster(CD), it is reclassified as a member of cluster(CD). Reflecting the change in the number of members in both clusters, cluster(AB) is renamed as cluster(A) and cluster(CD) is renamed as cluster(BCD). Their new cluster means are calculated and shown in the following table.

	Variable	**Variable**
Cluster mean	**X**	**Y**
(A)	5	3
(BCD)	(-1+1-3)/3 = -1	(1-2-2)/3 = -1

The squared distances are computed again between each observation A, B, C, D and cluster(A) and cluster(BCD) respectively. The results are summarised as follow.

Squared distance to cluster	**Observation A**	**Observation B**	**Observation C**	**Observation D**
(A)	0	40	41	89
(BCD)	52	4	5	5

Since observations B, C and D are closer to cluster(BCD), and observation A is the only member in cluster(A), no reassignment is needed and the final grouping is achieved.

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