

## BUILDING A HOUSE PRICES FORECASTING MODEL IN HONG KONG

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### INTRODUCTION

The purpose of building a house prices forecasting model is to estimate the impact of housing demand and housing supply in Hong Kong. The property market plays a very important role in the economy of Hong Kong. The real estate sector contributed approximately 10.2 per cent of GDP in 1996 (Hong Kong Government, 1998). More than 45 per cent of all bank loans, over HK\$500 billion as at the end of 1997, were directly tied to properties (Hong Kong Government, 1998). Income from land auctions, rates and stamp duties accounted for approximately 24 per cent of total Government revenue in 1997/1998 (Chan, et al., 2001). Property and construction company stocks contributed 25 per cent to Hong Kong's stock market capitalization as well as to over 60 per cent of capital investment expenditures (Newell and Chau, 1996). Smooth changes in house prices thus help to maintain stable economic growth in Hong Kong. To achieve a stable house price level, housing supply must match the demand for houses. However, house prices have at times been very volatile as a result of mismatched housing demand and supply in Hong Kong.

Figure 1 below shows the behaviour of real house prices and plots the quarterly time series data over the last two decades. It is

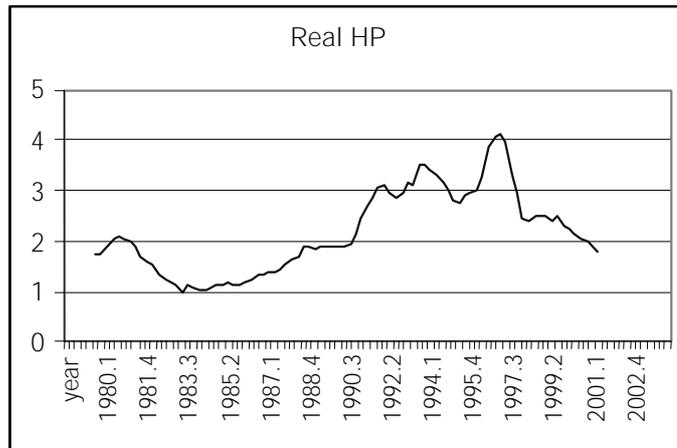
evident from Table 1 that there have been significant booms and busts since the late 1980s. The real price index of private residential property rose 87 per cent from the third quarter 1984 to the second quarter of 1989, 71 per cent from the third quarter 1989 to the third quarter 1992, and 50 per cent from the fourth quarter of 1995 to the third quarter of 1997. The reason for such growth during these periods was that the demand for houses was growing faster than supply and this generated speculative activity in the property market.

The periods of low prices were comparatively less volatile than the boom periods. Two dramatic declines have been observed, i.e., from the second quarter of 1981 to the fourth of 1983, with a real fall of prices of 47 per cent and a 42 per cent real fall in the third quarter of 1997. The Asian financial crisis restrained speculative activities dramatically as the suddenly decline in property prices changed assets into liabilities for many households. Consequently, households reduced their non-housing consumption and the lack of confidence in the economy as a whole created a vicious circle, further lowering the value of property. The house prices have dropped a further 18 per cent since then.

**Table 1: Housing Price booms and Busts (Source: Rating and Valuation Department, Hong Kong Government)**

	Time Period	% Change (Nominal)	% Change (Real)
Booms	4.79–2.81	50.0%	21.9%
	3.84–2.89	144.0%	86.6%
	3.89–3.92	128.6%	71.3%
	1.93–2.94	38.0%	25.7%
	4.95–3.97	65.9%	50.0%
Busts	2.81–4.83	-31.3%	-47.1%
	2.94–4.95	-12.4%	-22.3%
	3.97–4.98	-41.6%	-41.5%
	2.99–4.00	-24.8%	-18.4%

**Figure 1: Real Residential Housing Prices Index in Hong Kong (Source: Rating and Valuation Department, Hong Kong Government)**



It is an important role for the Hong Kong government to forecast the housing market and to provide a matching supply of land to the market. A house price forecasting model is one way this may be done.

The objective of this study is to develop a house prices forecasting model for Hong Kong. It starts from the assumption that housing in Hong Kong is traded in an efficient, free market. The first step is to identify, through a literature review, the variables that contribute to changes in the demand for and supply of houses. The second is to use a multiple regression for the empirical estimation. Quarterly time series data from 1980 to 2001 are used for the analysis. Some variables are transformed into logarithms and/or by use of moving averages to remove irregularities and/or seasonal patterns before application of the reduced form of the house prices model. The third step is to test the model by examining the significance of statistical indicators.

Three types of variables, namely macroeconomic indicators, housing related variables and demographic variables are used in the analysis. From these variables, eight models are derived for the analysis. These models indicate that household income, the size of the population, land supply, the Hang Seng Index and unit transaction volumes are the major indicators of changes in house prices.

### LITERATURE REVIEW

It is widely accepted that house prices are determined by the demand for, and supply of, houses in the property market. Thus,

prices will adjust to ensure that the market clears in the long run (Nellis and Longbottom, 1981). Bajic (1983) suggests that the market is not generally in short run equilibrium and that changes in housing prices are frequent and rapid, while DiPasquale and Wheaton (1994) suggest that there is, instead, a continuous adjustment as actual prices converge towards equilibrium prices.

The effective housing demand is the amount of housing for which the population is willing and able to pay. Individuals view housing not merely as a consumption good, but also, simultaneously, as an investment (Dusansky and Wilson, 1993). Reichert (1990) suggests that national economic factors such as mortgage rates, and local factors such as population shifts, employment and income trends have a unique impact on housing demand, and thus on housing price. The demand for housing also depends on factors like cost of mortgage finance, real incomes and the general level of consumer confidence ([www.tutor2u.net](http://www.tutor2u.net), 2002).

Muth (1960) concluded that housing demand is highly responsive to changes in income and prices. The empirical results indicate that the most important factor in the determination of house prices is real income because rising income increases the absolute value of the marginal rate of substitution between goods and owner-occupation. If household behaviour is consistent, then the appropriate income measure should be long run permanent income (Megbolugbe, et al., 1999).

Demographic variables such as family size and age composition are major determinants

of household consumption patterns (Pollark and Wales, 1981). Mankiw and Weil (1989) have found that aggregate demand growth would slow markedly as the baby boom generation grows older and reduces its consumption of housing. However, the conclusion has been criticised by most scholarly commentators (DiPasquale and Wheaton, 1994; Woodward, 1991; Engelhardt and Poterba, 1991). It is commonly accepted that an increase in household formation due to an ageing population, increasing numbers choosing to remain single and rising rates of divorce and separation will lead to increased demand for housing. Wong (1993) attributes the fast growth in demand during the boom in 1991 to a number of demographic as well as economic factors. In this study, the population age group 20 to 59 is used as representing demographic and permanent income factors because these people generally have sufficient savings and income to finance the purchase of houses. Hong Kong began to experience a surge of population in this home purchasing age group after 1986 (Wong, 1993) (Figure 2).

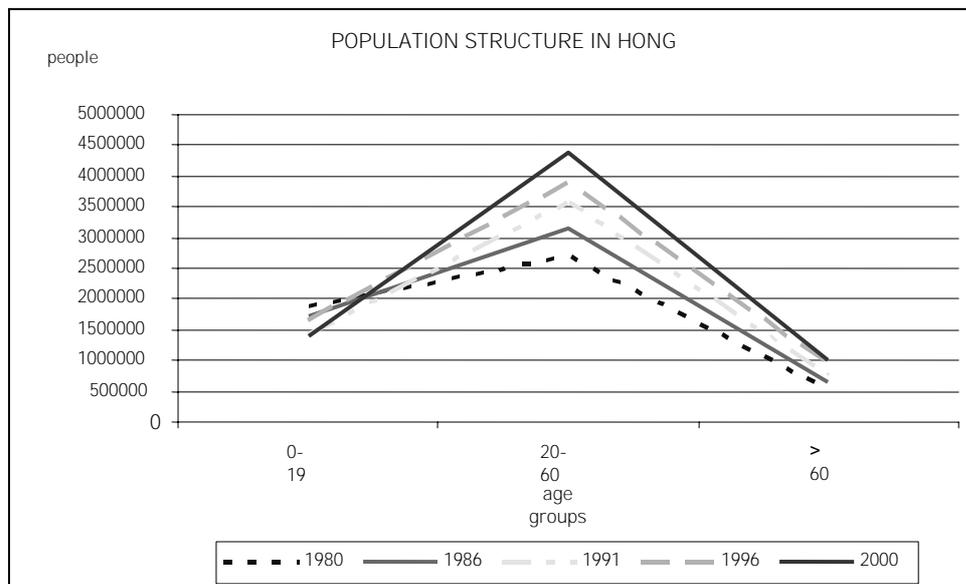
Expectations about the future direction of the economy affect current demand. Consumers are more likely to buy houses when they expect an expanding economy to provide them with both job security and rising income in the future. Government policy, inflation, interest rate changes and rate of return on property all have a great impact on consumer confidence and the demand

for housing (Wheeler and Chowdhury 1993). The stock market is another indicator of economic performance. An empirical study by Fu et al. (1993) found a pattern in which the stock market leads the property market in price change. Thus the Hang Seng Index is used as a proxy for macroeconomic impact in this study.

Housing price appreciation stimulates investment demand for houses. House price rises may lead to speculation, and speculation has been considered as a possible determinant of house price by number of authors such as Case and Shiller, (1989, 1990) and Levin and Wright (1997). Speculation opportunities arise from the gaps between the timing of purchase and sale contracts, circumstances where the expected growth rate in house prices exceeds the interest rate charged on bridging loans, and the opportunity to trade up without incurring any incremental transactions costs exists (Levin and Wright, 1997). Therefore, the transaction volume of residential properties in terms of the number of sales and purchase agreements in Hong Kong is adopted for this study.

Most homeowners use mortgages to finance their home purchase (Chan, 1996). To qualify for a mortgage, borrowers usually invest equity in a down payment (Harris and Ragonetti, 1998). The availability of mortgage credits and first down payment have been critical for housing investment demand.

Figure 2: Population age composition in Hong Kong, 1980–2000



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The effective demand for private housing is volatile, while the supply side is determined not only by the production decisions of builders of new dwellings but also by the decisions made by owners of housing concerning conversion of the existing stock, as housing is a durable good (DiPasquale, 1999). Supply side factors including vacancies, housing starts and interest rate all play a role in housing price movements (Ley and Tutchener, 2001).

Land supply has been addressed by Peng and Wheaton (1994) and Ho and Ganesan

(1998) in the Hong Kong housing market. They claim that the quantity of land supply determines housing prices. In Hong Kong, land is a highly scarce natural resource. Government land policy may impose a contrived effect on the supply of land. The Sino-British Joint Declaration stipulated that 50 hectares of land was the maximum that could be sold by the Hong Kong Government in a single year during the transition period (May 27, 1985 – June 30, 1997). Land leased by the Hong Kong Housing Authority for the construction of public rental housing was exempted from the land sales limit. In this study, residential units with consent to commence work, i.e., housing starts in terms of gross floor area, are taken as a proxy for land supply as suggested by Ho and Ganesan (1998).

## DEVELOPMENT OF A REDUCED FORM HOUSE PRICES FUNCTION

A reduced form equation for the price function is derived based on the supply and demand functions for owner-occupied housing and then inverted under an equilibrium assumption (DiPasquale and Wheaton, 1994). Table 2 shows that reduced form equations have been employed by many researchers in different applications. An example is Reichert (1990) who has used a reduced form equation to derive a regional housing prices model. He found that mortgage rates, population shifts, employment and income trends often have a unique impact on housing prices.

Many models of house price changes concentrate on demand factors (Muellbauer and Muphy, 1992) as supply factors are more difficult to measure. Some studies have utilized national aggregate time series data (Nellis and Longbottom, 1981; Buckley and Ermisch, 1983; Mankiw and Weil, 1989). Others have made use of pooled time series cross-sectional data (Case, 1986; Manchester, 1987; Reichert, 1990; Abraham and Hendershott, 1996).

To develop a house price reduced form model, the first step is to derive a demand equation. In accordance with literature review, the quantity demand for houses can be denoted as follows:

$$Qd = f(G, H, D, t) \quad (t = 1, 2, 3, \dots n) \quad (1)$$

$$G = g(x1, xi, \dots xm, t) \quad (i = 1, 2, 3, \dots m) \quad (2)$$

Table 2: Application of reduced form house prices model

Author(s)	Year	Title	Key Findings
Muth	1960	The Demand for Non-Farm Housing	Aggregate data, concluded that there is a perfectly elastic supply curve.
Follain	1979	The Price Elasticity of Long Run Supply of New Housing Construction	Aggregate annual data, the assumption of a perfectly elastic long run supply curve cannot be rejected.
Nellis and Longbottom	1981	An Empirical Analysis of the Determination of Housing Prices in the United Kingdom	Aggregate data, house prices is relatively more responsive to demand factor. The change in the price of houses lagged one period and nominal mortgage stock were found important in short run.
Ozanne and Thibodeau	1983	Explaining Metropolitan Housing Price Differences	Rent and house price indexes used to measure the variation among 54 metropolitan areas and able to explain 88% of the variation in rental prices and 58% of the variation in house prices.
Fortura. and Kushner	1986	Canadian Inter-City House Price Differentials	Identify the sources of inter-city house price differentials in Canada. Demand factors are important explanatory variables; a 1% increase in the income of households raises house prices by 1.11%.
Manchester	1987	Inflation and Housing Demand: A New Perspective	Nationwide time-series data cross cities. The interaction between taxes and inflation as well as cash-flow constraints has strong effects on the relative price of houses.
Manning	1989	Explaining Intercity Home Price Differences	Aggregated data, explanation for 84% of intercity variation in owner-occupied housing prices.
Reichert	1990	The Impact of Interest Rates, Income, and Employment upon Regional Housing Prices	Nationwide data, various regions respond in a similar fashion to certain national factors and suggest monetary and tax policy should take into consideration both national factors and regional trends.
Muellbauer and Murphy	1992	Booms and Busts in UK Housing Market	Housing demand is examined taking into account expectations, credit constraints, lumpy transactions costs and uncertainty.
Follain, Leavens and Velz	1993	Identifying the Effects of Tax Reform on Multifamily Rental Housing	Cross-section time series data. Examine the empirical relationship between rent and user cost. Changes in user cost significantly affect construction, but not the level of rents.
Case and Mayer	1996	Housing Price Dynamics Within a Metropolitan Area	Boston house price pattern. Changes in the cross-sectional pattern of house prices are related to differences in manufacturing employment, demographics, new construction, etc.
Malpezzi	1996	Housing Price Externalities, and Regulation in U.S. Metropolitan Areas	Cross-section analysis. Log transformed data, Increasing local market regulations of land increase home prices through increasing rents.

$$H = h(y1, yi, \dots, ym, t) \tag{3}$$

$$D = d(z1, zi, \dots, zm, t) \tag{4}$$

Therefore,

$$Qd = f(xi, yi, zi, t) \tag{5}$$

Where

$Q_d$  = aggregated quantity demand for new houses during period  $t$ ,

$G$  = macroeconomic variables,

$H$  = housing related variables,

$D$  = demographic variables,

$x_i$  = macroeconomic variables such as GDP, interest rate, Hang Seng Index, etc.,

$y_i$  = housing related variables such as house prices, permanent income, unemployment rate, etc.,

$z_i$  = demographic variables such as population, number of marriages, birth rates, etc.

It is assumed that homeowners maximize utility and investors maximize their profits (Reichert, 1990).

The method is applied for the supply equation as the second step. The supply of housing is a function of house prices, construction costs including interest rates, material costs and labour costs, and land supply.

$$Qs = f(S, t) \tag{6} \quad (t= 1, 2, 3, \dots n)$$

$$S = s(v1, vi, \dots, vm, t) \tag{7} \quad (i = 1,2,3, \dots m)$$

$$Qs = f(vi, t) \tag{8}$$

Where

$Q_s$  = aggregated quantity of new supply during period  $t$ ,

$S$  = Supply variables,

$v_i$  = variables such as house prices, construction costs and land supply.

Under an assumption of supply-demand equilibrium within the given period, i.e.,  $Q_d = Q_s$ , the functions (5) and (8) give a reduced-form price function:

$$P = f(Qd, Qs, t) \tag{9} \quad (t = 1,2,3, \dots n)$$

$$P = f(xi, yi, zi, vi, t) \tag{10} \quad (i = 1,2,3, \dots m)$$

Where

$P$  = house prices of new units sold during period  $t$  as dependent variable.

$x_i, y_i, z_i, v_i$  are the independent variables.

Assuming the generalized constant-elasticity demand function with a multiplicative relationship according to Reichert, (1990) gives:

$$P_t = \beta_0 x_{it}^{\beta_1} . y_{it}^{\beta_2} . z_{it}^{\beta_3} . v_{it}^{\beta_4} \tag{11}$$

The functional form in (11) can be converted into a linear equation suitable for estimation by standard multiple regression techniques by expressing it in logarithmic form. A one period lagged autoregressive error term  $P_{t-1}$  is applied to the model. Thus, the multiple population regression equation for houses demand becomes:

$$\ln P_t = \beta_0 + \beta_1 \ln x_{it} + \beta_2 \ln y_{it} + \beta_3 \ln z_{it} + \beta_4 \ln v_{it} + \beta_5 \ln P_{t-1} + \epsilon_t \tag{12}$$

Where

$\beta_0 \dots \beta_5$  represents the intercept and the regression coefficients (or elasticities) associated with their respective explanatory variables,

$\ln$  = the natural log of the continuous variables,

$\epsilon_t$  = the population disturbance term for quarter  $t$ . Where  $\epsilon_t \sim WN(0, \sigma^2)$ .

### Data Preprocessing and Estimating Procedures

Secondary data sources were utilised in the study. Unless specify, quarterly time-series economic indicators were abstracted from the "Hong Kong Monthly Digest of Statistics" compiled by the Census and Statistics Department in Hong Kong over the last two decades. The interpretation of each variable employed is as follows:

**Table 3: The percentage distribution of households by expenditure**

Index	Approximate percent of households covered	Monthly expenditure range in 1984/85
CPI (A)	50	\$2,000–\$6,499
CPI (B)	30	\$6,500–\$9,999
Hang Seng CPI	10	\$10,000–\$24,999

Source: Hong Kong Monthly Digest of Statistics

### General Economic Indicators:

- $GDP_t$  represents Gross Domestic Product at time  $t$  which is a measure of the total value of products of all resident producing units of a territory in a specified period, before deducting allowance for consumption of fixed capital. GDP is most widely used measure of economic performance. The growth in the GDP also underlines the viability of the housing market and lends support to the rising aspiration of home ownership. It is used as an independent variable together with Hang Seng Consumer Price Index ( $HCPI_t$ ) which is used to produce constant (2000 = 100) prices.  $GDPC$  (deflated by the HCPI) represents the gross value of investment expenditure in land, building and construction, plant, machinery and equipment by the public and private sectors in constant terms.

- There are three Consumer Price Index series derived from the Household Expenditure Survey, defined in terms of the percentage distribution of households by expenditure as shown in Table 3. The remaining 10 percent of households at the top and bottom of the expenditure scale are excluded. The Hang Seng Consumer Price Index ( $HCPI$ ) is used in this study because it represents the expenditure group most likely to affect private housing prices.

- Hang Seng Index ( $HSI$ ) is compiled by the Hang Seng Bank Ltd based on information on share prices supplied by The Stock Exchange of Hong Kong.  $HSI$  covers 33 blue chip stocks listed on the Exchange and is weighted by market capitalization. The last data for each quarter are used for this study.

- Median Monthly Domestic Household Income ( $HHI_t$ ) is the median household income which represents purchasing power in the period  $t$ . Real household incomes are constructed by dividing the household incomes by the Hang Seng Consumer Price Index ( $HCPI$ ).

- The interest rate  $r_t$  is the best lending rate at the period  $t$ , expressed as per cent per annum. The Hong Kong dollar is linked to the U.S. dollar hence the local interest rate is beyond the government's control. House prices will increase when mortgage and interest rates decline and the property market will slow down when mortgage rates rise. Therefore it is expected to have a negative

sign. Real interest rate is the nominal rate ( $i_t$ ) minus inflation rate ( $i_f$ ). That is:

$$r_t = i_t - i_f \quad (13)$$

$$i_f = \frac{CPI_t - CPI_{t-4}}{CPI_{t-4}} \quad (14)$$

The real mortgage rate ( $rm$ ) is derived by dividing nominal mortgage rate ( $im$ ) by the HCPI, i.e.:

$$r_{mt} = \frac{i_{mt}}{HCPI_t} \quad (15)$$

### Demographic Factors

- The demographic variables such as total population ( $GPL_t$ ), people at age group of 20–59 ( $PL_t$ ), marriages ( $MN_t$ ) and number of births ( $BN_t$ ) at the period  $t$  respectively are considered. Increasing demographic factors will increase the pressure on house prices. Only mid-year and end-year population figures are available. Quarterly figures are calculated as follows:

$$GPL_t = GPL_{t-1} + \frac{GPL_{t+1} - GPL_{t-1}}{2} \quad (16)$$

The figures relating to births, deaths and marriages refer to such events as were registered with the Director of Immigration every quarter. Seasonal adjustment is made to eliminate seasonal effect.

### Housing Related Factors

- Statistics on price and rental cost indices for private domestic premises are provided by the Rating and Valuation Department, Hong Kong. There are four types of private domestic premises that are listed in Table 4. The overall price indices are used for the study. Real housing prices ( $HP$ ) are derived by dividing nominal prices by the Hang Seng Consumer price index ( $HCPI$ ).

- A sudden scarcity of land raises housing prices because of suppressed current housing production and higher investment demand (Peng and Wheaton, 1994). Thus, the availability of land is an important factor to be considered in the model. Consent to commence work on residential flats is used as a proxy of land supply ( $LS$ ). The measurement of land supply is defined as the total gross floor area of land supply actually put to the market (Ho and Ganesan, 1998).

Table 4: Property price indices for private domestic premises

Private Domestic Premises (square meter) (1989=100)					
Year	Up to 39.9	40–69.9	70–99.9	100 & above	Overall
1992	210	219	229	205	215
1993	223	244	261	250	237
1994	263	306	341	351	293
1995	252	282	306	314	272
1996	269	310	334	352	298
1997	376	435	488	514	420
1998	274	308	336	348	299
1999	231	265	287	302	257

Sources: Hong Kong Monthly Digest of Statistics, various issues

- Number of houses completed ( $HS_t$ ) is the major measure of housing supply. It is relatively inelastic in the short run; this is because there are time lags between a change in price and an increase in the supply of new properties becoming available, or homeowners deciding to put their properties onto the market. The long run impact on prices depends on the supply response determined by the price elasticity of supply (DiPasquale, 1999).

- The construction cost index is sourced from Levett and Bailey Chartered Quantity Surveyors Ltd in Hong Kong. Their tender price index is a quarterly weighted index that measures the costs of building material, labour costs, plant costs, rents, overhead costs and taxes.

### Other Indicators

- Political events ( $PO$ ) contribute to house price fluctuations such as occurred when housing prices kept falling from 1981 till the end of 1984 because of uncertainty over Hong Kong's political future after the Sino-British negotiations over Hong Kong in 1997, or the property boom after the Sino-British Joint Declaration in 1985. The Tiananmen Square events caused an immediate but brief fall in property prices. Hence it is evident that Hong Kong's housing market is highly responsive to changes in the political climate (Chou and Shih, 1995). In the analysis,  $1$  indicates the occurrence of an event and  $0$  indicates otherwise.

- Confidence is vital in the housing sector. What people think will happen in the future influences current purchasing decisions. It is not an input variable for the house prices

equation because confidence is hard to quantify.

The details variables description is in the Table 5.

### Date Transformation

To make them more suitable for quantitative analysis, the data are examined and transformed or manipulated as required. All data are examined to establish (a) whether the data for individual variables are normally distributed; and (b) whether the independent variables are linearly related to the dependent variable. Data are transformed through the following methods:

- 1) Log transformation of variables to make relationships linear, such as house price index and rental index;

- 2) Moving average to minimize the effect of seasonal and irregular variations, thereby indicating the data's general trend. For example, new house completions where a 4-year moving average eliminates, to a great extent, the fluctuations in the original data. The equation is:

$$y_t = \frac{1}{4} \sum_{i=0}^{p-1} x_{t-i} \quad (t = p, \dots, n) \quad (17)$$

Where there are  $n$  values in a time series  $x_1 \dots x_n$ .

The centred moving average is applied to match time series (Waxman, 1993). The moving average will be distorted by any unusual events occurring during the time under consideration, thus any unusual curve can be detected if there is policy change or some special event occurred in the period.

Table 5: Definition of variables

Type	Name	Definition
$y_i$	PO	Political events. 1 if occurs, 0 otherwise.
	HP	The Private Housing Price Index (1989=100), inflation adjusted.
	R	The Private Rental Index (1989=100), inflation adjusted.
	U	Unemployment Rates (percent)
$z_i$	GPL	Total Population Number
	HN	Household Number
	PL	Population Number age at 20–59 who are the sources of income group.
	MN	Number of Marriages
	BN	Number of Births
$x_i$	Y	The Median of Household Income, Hong Kong Dollars per household
	HSI	Hang Seng Index (1964=100), inflation adjusted.
	GDP	Gross Domestic Product at constant 2001=100, Hong Kong Dollars Million
	GDPC	Gross Domestic Product – construction. Hong Kong Dollars Million
	HCPI	Consumer Price Index (10.1999–09.2000=100)
	r	The Mortgage Rates percent per annum from Hang Seng Bank, inflation adjusted.
$v_i$	LS	Land supply for private residential development. Residential units/flats with consent to commence work by floor area (square meter) as proxy.
	HS	Residential Units Completed by Private Number of Units
	C	Construction Cost Index (1968=100), inflation adjusted.

3) Differencing technique, i.e., by subtracting a lagged version of the series from the original time series data. A new time series is created from the first difference (or the difference of order 1) such as changes in housing completion.

$$z_t = y_t - y_{t-1} \quad (18)$$

Similarly, a difference of order 4 can be derived by:

$$z_t = y_t - y_{t-4} \quad (19)$$

The inflation rate is determined using this technique.

4) Principle component analysis is adopted for selecting best effective variables. It is applied to avoid the use of variables with strong positive relationships as such relationships may reduce the validity of the model. Many indicators, especially macro economic variables, are strongly correlated. When this is the case, the calculated coefficients may not represent a true causal relationship between dependent and independent variables. This type of analysis

can separate the nature of variables by making categories and give extraction sums of squared loadings for considering variable selection.

5) There are leading, coincident and lagging characteristics of indicators. To ensure that the economic indicators truly reflect the growth or decline of housing prices, the degree of time lag or lead should be established. Pearson correlations are produced to test if there are significant correlations between the dependent and independent variables, and to find lead/lagged relationships between variables. The correlation value is considered significant if the  $p$  value is less than 0.05.

### Estimation Procedures

The forecasting procedures are depicted in Figure 3. A reduced-form model is a specific forecasting system used for the stochastic simulation for housing prices based on economic indicators.

Figure 3: Depicts procedures for the housing prices forecast using log-linear model.

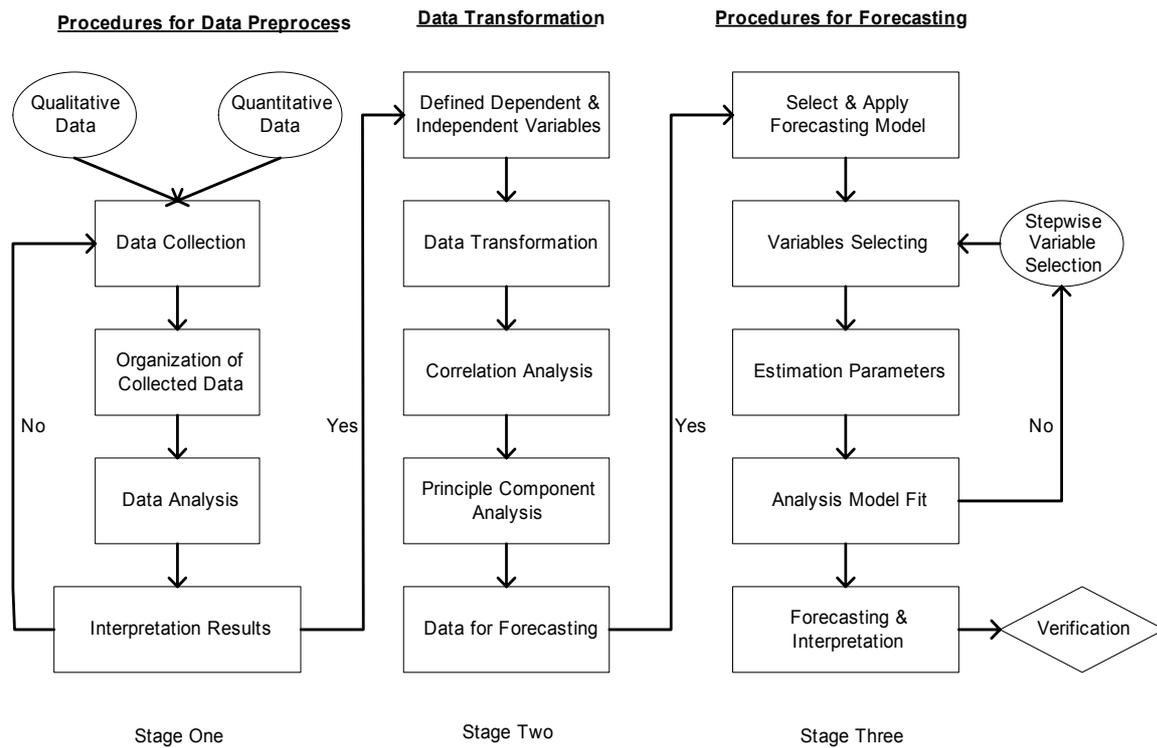
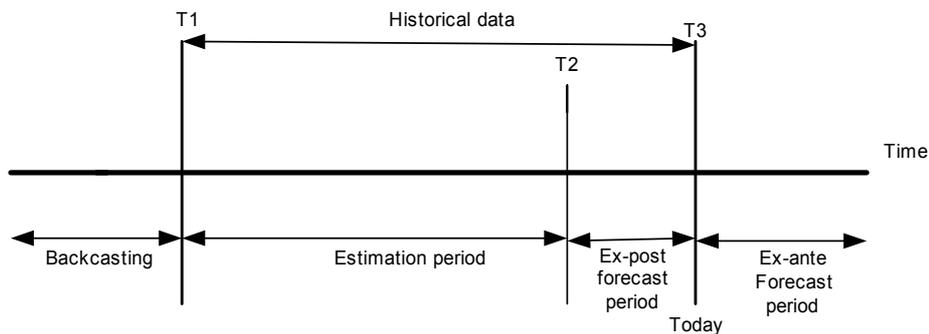


Figure 4: Periods of forecasting



Source: Pindyck and Rubinfeld, 1991

To test the accuracy of the forecasting models, 80 per cent of the historical data are used for estimation and 20 per cent of the data are adopted for ex-post forecasting. Ex-ante forecast will be applied for analysis of policy implication as showed in Figure 4.

Stepwise selections are used. The decision to enter or remove variables in the model is based on how much they contribute to multiple  $R^2$  and on  $F$  and  $t$  values.

The mean squared error (MSE) and adjusted  $R^2$  ( $\bar{R}^2$ ) are employed as criteria in the examination of the model fit. MSE is used because it effectively estimates out-of-sample

mean square prediction error—the smaller the better (Diebold, 1998).

$$MSE = \frac{\sum_{t=1}^N e_t^2}{N} \tag{20}$$

where  $N$  is the sample size and

$$e = HP_t - \hat{HP}$$

$$\bar{R}^2 = 1 - \frac{s^2}{\sum_{t=1}^T (HP_t - \bar{HP})^2 / (N - 1)} \tag{21}$$

where  $s^2$  is the variance.  $R^2$  is the coefficient of determination which expresses the

proportion of the total variation in the dependent variable that is explained. Adjusted  $R$  squared is an estimate of how well the model would fit from the same population. Thus, minimizing the standard error of the regression maximizes adjusted  $R$  squared to establish the model with the best fit.

### Empirical Results

The ordinary least-squares regression method is employed in this analysis. The advantage of the least-squares method is that it expresses the secular trend in a mathematical formula which permits objective extrapolation into the past, present and future. The disadvantage is that it is based on the assumption that all variables have linear relationships which is not always the case.

Table 6 shows three sets and a total of eight models, chosen from many derived models. The dependent variable is the real private residential house price index (1989=100). The models are significant at the 95 per cent confidence level. The independent variables are different in each case for the purposes of comparisons.

Case one uses the population of age 20–59, land supply, mortgage rate, Hang Seng Index and units of transactions as independent variables. It is found that both the  $F$  test and the  $t$  test for each variable, except the mortgage rate, are statistically significant and have the expected signs. A one per cent increase in population during the given period is associated with a 2.67 per cent increase in housing prices during the same period. A one per cent decrease in land supply during the given period is associated with 0.104 per cent increase in housing prices during the same period. A one per cent increase in the Hang Seng Index and unit transactions volume during the given period are associated with 0.36 and 0.258 per cent increase in housing prices during the same period respectively, *ceteris paribus*. The implications are (1) the higher the population and the higher the permanent income, the higher the housing prices; (2) there are speculative activities in the housing market; (3) macroeconomic factors impact on housing prices. The problem in this model is that mortgage rate does not have the expect sign. The Durbin-Watson test rejects the null ( $\rho=0$ ) hypothesis.

Case two uses the same variables as case one but increases the time span (sample sizes) from 63 to 75 quarters, which improves the Durbin-Watson test. To further improve the Durbin-Watson result, the real housing price, lagged one period, is applied. The Durbin-Watson reaches 1.68 which is in the inconclusive range. However, the negative sign of population variable for models 3–8 has indicated that there may be problems with multicollinearity in the model.

In cases four to eight, different variables are tested in the model. It is found that household income is significant, i.e., a one per cent increase in household income at a given period is associated with a 1.97 per cent increase in housing prices for the same period. An interesting finding is that political events have positive impacts on housing prices. However, there are negative signs on the total size of population.

The demographic factors indicate great changes in Hong Kong during the past two decades. It is implied that the size of the total population may not be the best proxy in building house prices model. The reasons are as follows:

#### (a) Population Ageing

The proportion of the population aged 65 and over has grown progressively (Champion, 2001) in Hong Kong, from 8 per cent to 11 per cent from 1988 to 1999 (Department of Census and Statistics, April 2001). This age group is mostly staying at government public housing or living with their children, rather than adding to the demand for housing.

#### (b) Children of School Age

This age group is decreasing in relative terms. The proportion of people aged less than 19 fell 25 per cent from 1980 to 2000 and the birth rate is declining, from 1.2 per cent in 1989 to 0.8 per cent in 1999 in Hong Kong (Department of Census and Statistics, April, 2001).

#### (c) Changes in Marriages Rates

Marriage rates have decreased continuously over the past ten years. The median age at first marriage for men increased from 28.6 in 1988 to 29.8 years in 1998, and for women from 25.8 to 26.9 years, indicating a trend towards later marriages (Census and Statistics Department, 1999).

Table 6: Regression Results with Dependent Variable = LOGHP

Variables	Expected Sign	82-2001			80-97			80-2001	
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Constant		-18.55 (-4.2)	-10.92 (-3.3)	2.04 (2.85)	-3.269 (-7.99)	-2.911 (-6.02)	-3.423 (-11.4)	-3.504 (-13.2)	-3.437 (-8.4)
LOGPL	+	2.674 (3.85)	1.46 (2.78)	-0.482 (-4.3)					
LOGGPL	+				-4.566 (-5.01)	-4.55 (-4.17)	-4.634 (-6.93)	-3.829 (-10.3)	-3.339 (-6.08)
LOGLS	-	-0.104 (-2.2)	-0.155 (-3.7)						
LOGR	-	0.875 (4.2)	0.871 (3.92)	0.15 (2.96)	0.361 (4.40)	0.322 (3.29)	0.375 (6.23)	0.399 (7.50)	0.403 (4.9)
LRHP <sub>t-1</sub>	+			0.835 (36.9)					
LOGHHI	+			0.253 (3.44)	1.98 (12.34)	1.954 (10.16)		1.852 (23.2)	1.799 (15.03)
LOGLS <sub>t+2</sub>	+				0.0886 (5.16)	0.105 (5.16)	0.102 (8.21)	0.10 (8.83)	0.0877 (4.84)
LOGHSMA	-				-0.201 (-2.69)	-0.275 (-3.12)	-0.162 (-2.95)	-0.131 (-2.87)	
POLICY	+/-				0.0081 (5.46)		0.009 (10.53)	0.0087 (11.96)	0.0068 (4.94)
LOGHHI <sub>t+2</sub>	+						1.972 (16.74)		
LOGHSMA (t+1)	-								-0.153 (-2.17)
LHSI	+	0.36 (3.15)	0.292 (2.78)	0.074 (3.4)					
LSP	+	0.258 (3.39)	0.419 (6.77)	0.121 (8.81)					
Adjusted R <sup>2</sup>		0.854	0.81	0.992	0.962	0.946	0.980	0.981	0.955
D-W Ratio		0.566	0.757	1.678	1.413	0.922	1.465	1.451	1.648
F-Ratio		74.99	65.1	1606	302.03	248.08	569.33	732.89	298.26
Sample size		63	75	75	71	71	71	84	84

**(d) Migration**

Mainland China is the major source of immigrants. In 1999, 54,625 mainland residents came to settle in the Hong Kong under the one-way permit scheme (Census and Statistics Department, 2001). The population will continue to increase, however, new immigrants may not have much purchasing power.

Though the models have indicated significance in terms of adjusted  $R^2$  and  $t$  tests, the unexpected sign in some of the models implies that there may be a problem of multicollinearity in the models. Multicollinearity is the correlation among the independent variables. It can distort the standard error of estimate and may, therefore, lead to incorrect conclusions as to which independent variables are statistically significant. It is

suggested that the ordinary least square method may not be suitable for a housing prices model in the Hong Kong situation.

## CONCLUSION

This study has attempted to construct house price forecast models for Hong Kong. All selected variables were transformed into logarithms before applying the multiple log-linear functional forms (Anas and Eum, 1984; Harrington, 1989) of regression analysis. In the study it is found that macroeconomic elements such as the Hang Seng Index and household income have impacts on housing prices. Demographic variables, such as population of age 20–59, are also significant, while housing related factors such as land supply, and unit transaction numbers and completion of new houses are the main variables that influence house prices. Over the study period, policy factors have also been important for the fit of the models. The implication is that the Hong Kong Government may formulate a stable and suitable long term housing policy. Land policy may affect investment demand for housing and therefore influence house prices.

Of the eight models, five (3, 4, 6, 7 and 8) are statistically satisfactory. However, it is indicated that there may be a problem of multicollinearity built into the models which suggests that they can be improved through co-integration, error correction models. An alternative method that could be considered is an artificial neural network model.

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