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Housing Market of Hong Kong - Dynamic Modeling and Forecasting

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Abstract

Housing price of Hong Kong has been ranked the most expensive in the world and the main focus of the government, organizations and public. The sky-rocketing housing price has been a great concern of most people. A reliable and efficient model to estimate the housing prices would certainly capture great interests of Hong Kong and the world. It would be used as reference for purchasing and investment decisions of house buyers.

This paper starts with setting a hypothesis of a multiple linear regression model expressing housing prices in terms of a number of explanatory variables. Based on literature review, main factors affecting the housing prices from the perspectives of supply and demand are identified. Empirical data of these factors will be collected from various sources including Trade Economics, Centaline Property Agency Ltd, Rating and Valuation Department, and Transport and Housing Bureau on four big housing estates in West Kowloon of Hong Kong - Liberté, Banyan Garden, The Pacifica and Aqua Marine - between the year 2002 and 2014. The data will be used to testify the validity of the literature review as well as the model. Correlation test among the explanatory variables are performed before suitable explanatory variables are chosen and used to testify the validity of the model using R-software.

Results concluded that the following five explanatory variables – Real interest rate (RIR), Affordability Index (AI), Transaction Volume (TV), Gross Domestic Product Per Capita (GDPPC), Private Domestic Rental Index (PDRI) – are reliable factors in affecting housing prices in Hong Kong with R Square of 0.9307 and Adjusted R Square 0.8812; The model is satisfactory and reliable in using five explanatory variables in affecting the housing prices in Hong Kong.

I. Introduction

In Shlomo Angel (2014), it had concluded that Hong Kong citizens' incomes are most difficult in affording a housing unit in the city. The high housing price affects the people's livelihood that sub-divided units are popular nowadays.

Given the sky-rocketing housing prices, most mid-to-lower income people are not affordable to buy their own flats. Given the seriousness of the problem, this paper is going to conduct a comprehensive model to predict the housing prices in Hong Kong.

This paper aims to set up a hypothesis assuming a linear multiple regressions between the property prices and a number of independent explanatory variables. A series of steps are performed before reliable explanatory variables are identified. These include literature review and performance of multi-correlation test among these variables.

Due to limited resources, we need to keep our study more focused. To ensure that there is sufficient transaction volume and to make comparison of housing prices earlier, four housing estate in West Kowloon (Lai Chi Kok) of Hong Kong with similar location and facilities, namely Liberté, Banyan Garden, The Pacifica and Aqua Marine, were studied. Since the housing estates were not ready until the year of 2002, relevant data will be collected only between the year 2002 and 2014.

Independent variables were selected after the study of the relevant literature review and performance of multi-correlation test. A linear multiple regression model with estimation of housing prices expressing in terms of explanatory variables of Real Interest Rate (RIR), Affordability Index (AI), Transaction Volume (TV), Gross Domestic Product Per Capita (GDPPC) and Private Domestic Rental Index (PDRI). Data on these variables will be collected from Hong Kong Rating and Valuation Department and The Centaline Property Agency Ltd, one of the leading Property Agencies in Hong Kong, between year 2002 and 2014 to test the hypothesis. Results will be analyzed with conclusions made in predicting the housing price in Hong Kong. It can be used as reference for predicting and estimating housing price for government, private and individual investment decisions.

II. Methodology

Based on literature reviews, suitable independent explanatory variables and their impacts on housing prices were identified. Empirical data of these explanatory variables between the year 2002 and 2014 were collected and studied to testify the validity of the variables and conclusions of the literature review. Correlation test among these variable were also performed. Explanatory variables with high correlations are discarded from considerations to avoid regression results being exaggerated. A hypothesis of housing prices (PP) being expressed in terms of linear multiple regression of these variables is set up as follows:

$$Y(PP)_t = a + b\,X_1(RIR)_{t-1} + c\,X_2(GPCPC)_{t-1} + d\,X_3(AI)_{t-1} + e\,X_4(LSF)_{t-1} + f\,X_5(HCF)_{t-1} + g\,X_6(PDRI)_{t-1} + h\,X_7(TV)_{t-1} + \varepsilon$$

Data of the variables would be collected and inputted in the hypothesis to explain the housing price using R software. Results would be analyzed with conclusions made.

Explanatory Variables

By the literature view, the followings are identified as factors affecting the housing price in Hong Kong.

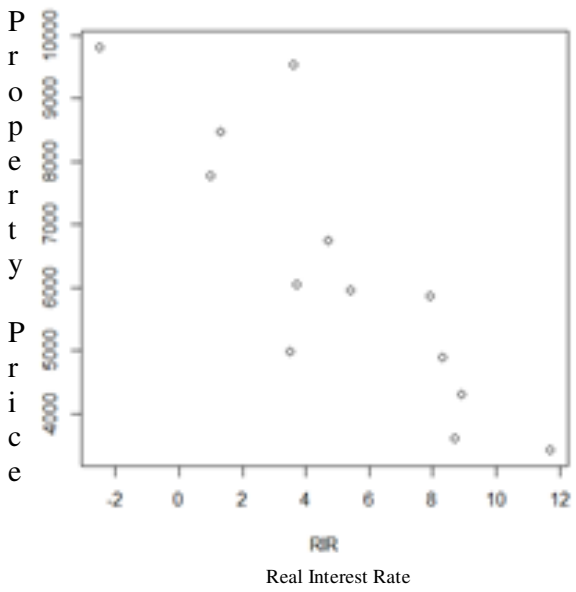
1. Real Interest Rate (RIR)

Real interest rate represents the real return of investors for holding cash placed with banks. Negative real interest rate discourages investors for holding cash and stimulates investors to seek alternative investment including purchasing properties for rental returns and capital appreciation. It is therefore expected that property prices is *inversely* related to real interest rate. By Sum K.C. (2006), housing price is affected by the real interest rate. Himmelberg, C.C., Mayer, and T. Sinai (2005) suggest that low real interest rate is a strong stimulus, which increases the housing demand directly.

$$\textbf{\textit{Real Interest Rate}} = \left[\frac{(1 + \textit{nominal interest rate})}{(1 + \textit{inflation rate})}\right] - 1$$

Theoretically,

or Real interest rate ≈ Nominal interest rate - Inflation rate



Results: By R-Software

Call:
lm (formula = PP ~ RIR)

Residuals:

Min	1Q	Median	3Q	Max
-2009.74	-385.13	37.33	294.85	2586.48

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	8617.3	522.2	16.501	4.16e-09	***
RIR	-462.1	82.4	-5.609	0.000158	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1121 on 11 degrees of freedom
Multiple R-squared: 0.7409, Adjusted R-squared: 0.7174
F-statistic: 31.46 on 1 and 11 DF, p-value: 0.0001582

Graph 1: Property Price (PP) versus Real Interest Rate (RIR)

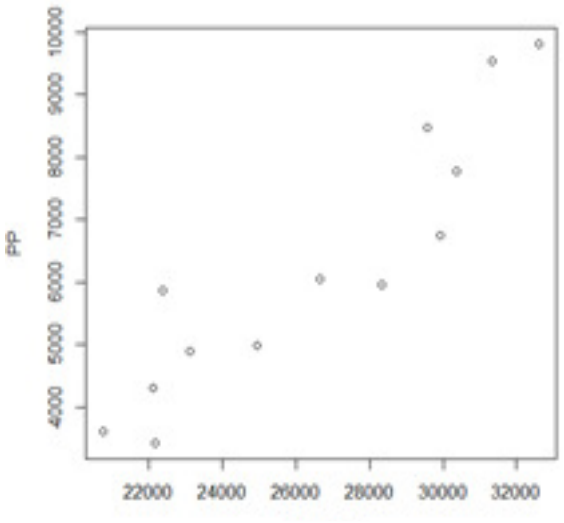
Empirical testing using R software shows that Property Price (PP) is inversely proportional to the Real Interest Rate (RIR). Increasing one unit of Real Interest Rate (RIR) decreases 462.1 Property Price (PP).

Graph 2: Inflation and Interest rate of Hong Kong between year 2001 and 2014
(Source: http://www.tradingeconomics.com/hong-kong/real-interest-rate-percent-wb-data.html

Empirical data shows that real interest rate was substantially negative between year 2001 and 2014 leading to rising housing prices in the years.

III. Gross Domestic Product Per Capita (GDPPC)

Woo and Chan (2011) state that the growth in GDP causes the long run rise in the prices of houses. Strong economic growth tends to stimulate demand for houses, which in turn propels property prices. As such, GDP would be used as a factor to estimate the housing prices in Hong Kong.



Results: By R-Software

Call:
lm(formula = PP ~ GDPPC)

Residuals:

Min	1Q	Median	3Q	Max
-1184.67	-540.03	49.49	648.84	1532.77

Coefficients:

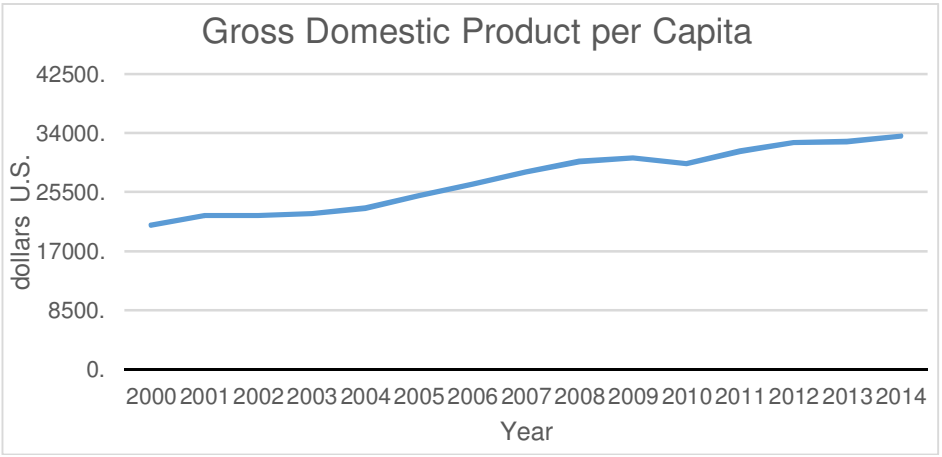
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-6.250e+03	1.627e+03	-3.842	0.00274	**
GDPPC	4.726e-01	6.076e-02	7.778	8.53e-06	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 863.8 on 11 degrees of freedom
Multiple R-squared: 0.8461,
Adjusted R-squared: 0.8322
F-statistic: 60.5 on 1 and 11 DF, p-value: 8.528e-06

Graph 3: Property Price (PP) versus GDP Per Capita (GDPPC)

Empirical testing using R software shows that Property Price (PP) is *directly proportional* to the GDP per capita (GDPPC). Increasing per unit of GDPPC increases 4.726e-01 PP.



Graph 4: GDP Per Capita (GDPPC) between year 2000 and 2014
(Source: Trading Economics, Hong Kong GDP per Capita)

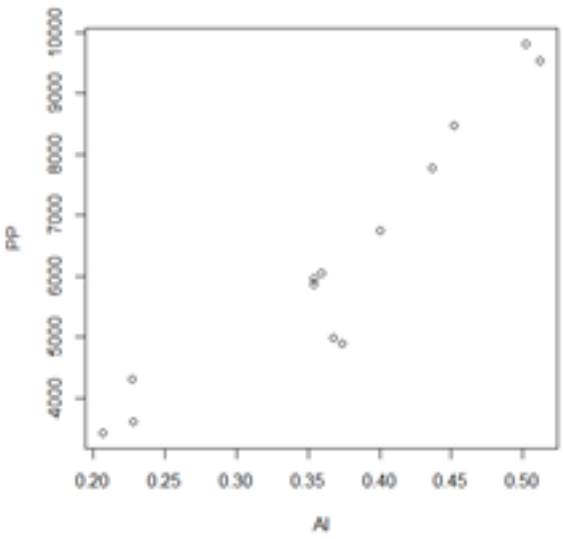
Note that a rising GDP Per Capita might be caused by increased in price index or inflation ; rising GDP may not necessarily imply an increased in standard of living.

IV. Affordability Index (AI)

By Sum K. C. (2006), housing price is affected by affordability index. A measure of a population's ability to afford to purchase a particular item, such as a house, indexed to the population's income. An affordability index uses the value of 100 to represent the position of someone earning a population's median income, with values above 100 indicating that an item is less likely to be affordable and values below 100 indicating that an item is more affordable. There are many different ways to measure affordability index. The higher affordability index means the lower affordability of purchasing housing property. A high percentage of affordability index implies many citizens cannot afford to purchase housing property which also indicate that the housing price is too high.

In Alice, Y. Y. Cheung (1996) and Sum, K.C. (2006), both defined Hong Kong's Affordability Index as the monthly mortgage payment on an average flat divided by median household monthly income.

Affordability Index (AI) = Mortgage payment (on an average flat) / (Median Household) Income



Results: By R-Software

Call:
lm(formula = PP ~ AI)

Residuals:

Min	1Q	Median	3Q	Max
-1499.8	-138.1	105.0	384.0	862.4

Coefficients:

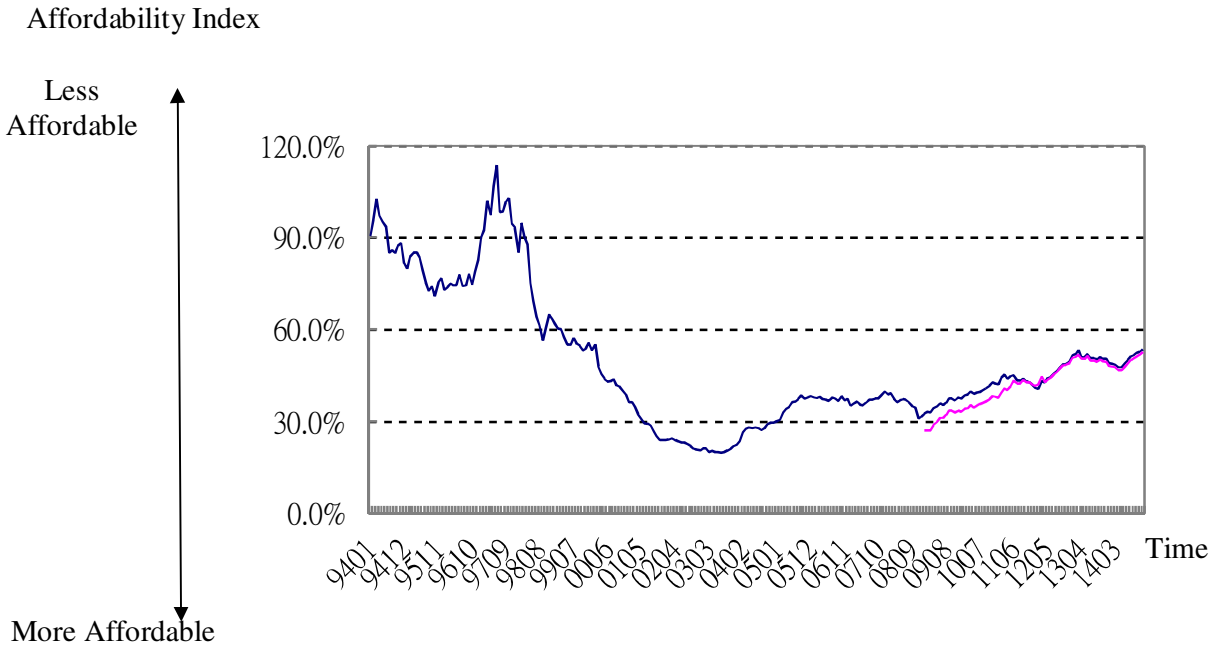
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-1111.2	816.6	-1.361	0.201	
AI	20082.8	2152.6	9.329	1.47e-06	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 737.7 on 11 degrees of freedom
Multiple R-squared: 0.8878,
Adjusted R-squared: 0.8776
F-statistic: 87.04 on 1 and 11 DF, p-value: 1.472e-06

Graph 5: Property Prices (PP) versus Affordability Index (AI)

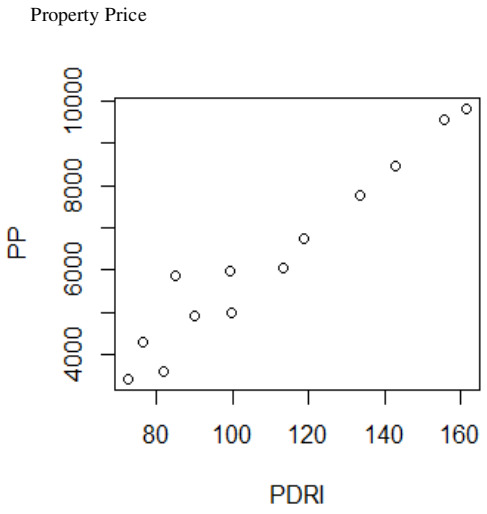
Empirical testing using R software shows that Property Price (PP) is *directly proportional* to the Affordability Index (AI). Increasing per unit of AI increases 20082.8 PP. When housing price is increasing, each unit of family affords a higher percentage of mortgage payment.



Graph 6: Affordability Index (AI) between year 1994 Q1 and 2014 Q3
(Source: Market Statistics Department, Centaline Property Agency Ltd)

V. Private Domestic Rental Index (PDRI)

Gallin (2004) uses rental index as an indicator to observe the housing rents. The paper uses rent-price ratio to analyze the housing prices. Changes in real rents tend to be larger than usual and changes in real prices tend to be smaller than usual. Therefore, the rental index would have a relationship with the housing prices.



Results: By R-Software

```
Call:
lm(formula = PP ~ PDRI, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-760.00 -310.23   -7.65  189.50 1287.70

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -1173.100    584.320  -2.008   0.0699 .
PDRI           67.564      5.132  13.165 4.46e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 538.2 on 11 degrees of freedom
Multiple R-squared:  0.9403,    Adjusted R-squared:  0.9349
F-statistic: 173.3 on 1 and 11 DF,  p-value: 4.463e-08
```

Graph 7: Property Prices (PP) versus Rental Index (RI)

Empirical testing using R software shows that there is *positive* correlation between Private Domestic Rental Index (PDRI) and the Property Price (PP). An increase per unit of PDRI increases $67.564 PP.

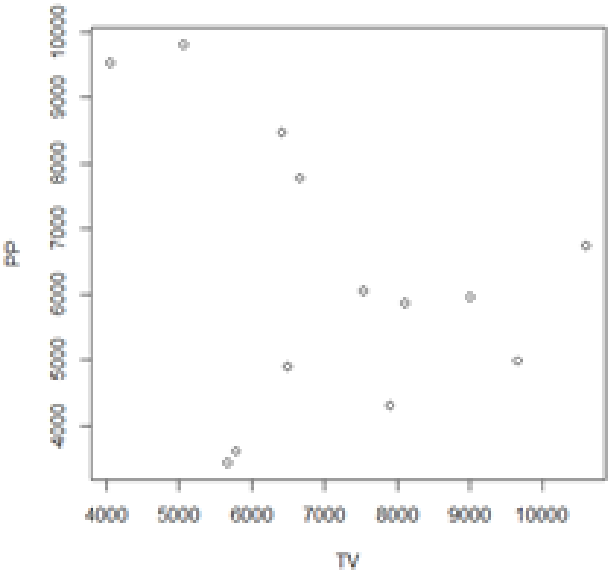
Private Domestic Rental Index

Graph 8: Private Domestic Rental Index (PDRI) over the year 2002 and 2014
(Source: Rating and Valuation Department, Private Domestic Rental Index)

The private rental domestic index has been increasing between year 2003 and 2008. But, there was an obvious drop in year 2008 due to the financial crisis in the West.

VI. Transaction Volume (TV)

In Akkoyun, Arslan, and Kanik (2013), it was shown that there exists correlation between housing prices and transaction volume. By reviewing transaction volume, demand of property can be reflected by the implementation of property policy.



Results: By R-Software

Call:
lm(formula = PP ~ TV)

Residuals:

Min	1Q	Median	3Q	Max
-3364.6	-1595.3	-61.5	1709.0	2801.6

Coefficients:

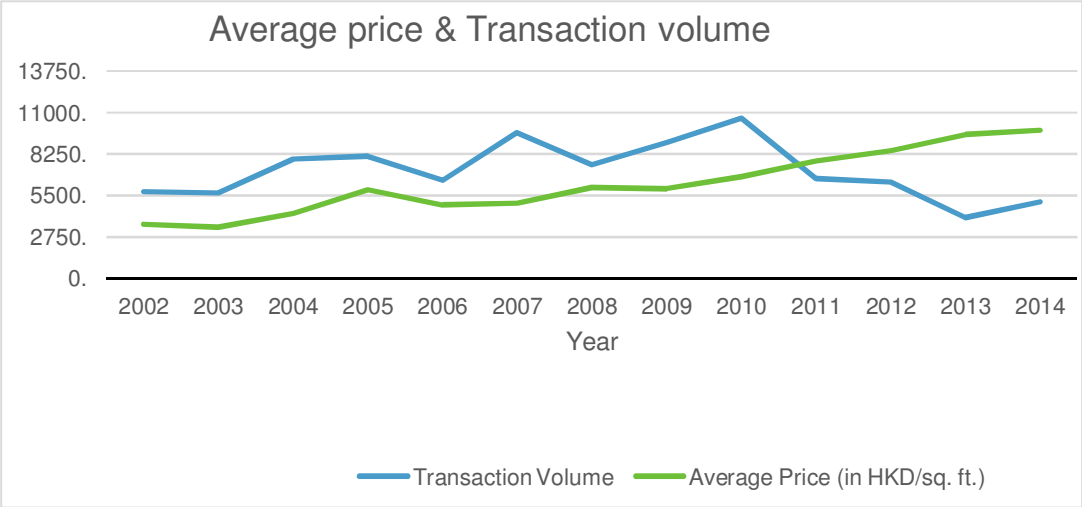
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	8815.5854	2358.4192	3.738	0.00328 **
TV	-0.3571	0.3199	-1.116	0.28816

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2087 on 11 degrees of freedom
Multiple R-squared: 0.1017,
Adjusted R-squared: 0.02007
F-statistic: 1.246 on 1 and 11 DF, p-value: 0.2882

Graph 9: Property Prices (PP) versus Transaction Volume (TV)

Empirical testing using R software shows that transaction volume *does not have* an obvious relationship with the housing price. Property Price (PP) is inversely proportional to the Transaction Volume (TV). Increasing per unit of TV decreases 3364.6 PP.

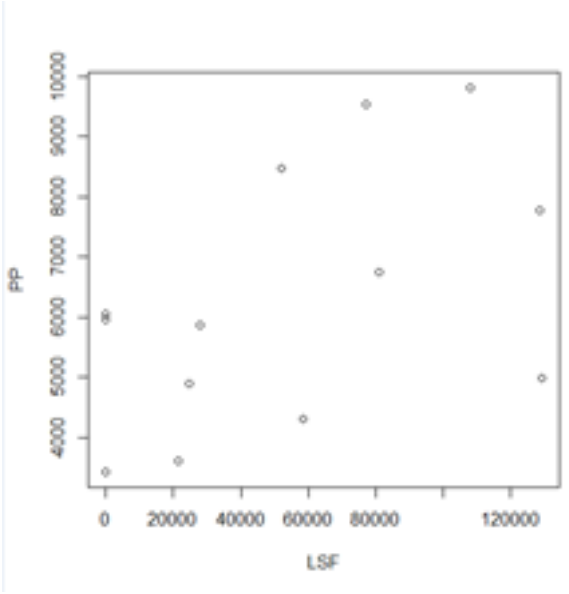


Graph 10: Average transaction housing price (PP) between year 2002 and 2014
(Source: Rating and Valuation Department, HKSAR: Domestic Sales – Number of Sale and Purchase Agreements and Total Consideration)

Before year 2010, the average price and the transaction volume both have an increasing trend. After year 2010, transaction volume has a great drop but housing price kept rising. The decrease of transaction volume accumulates more than a half of transaction volume at 2010 and continue to drop until 2013. On the other side, the average price continues to increase at 2010 to 2013 when the transaction volume is decreasing.

VII. Land Supply Figure (LSF)

By Peng and Wheaton (1994), Hong Kong government plays a leading position in land supply via housing policy since it is the sole supplier of land and largest land owner of Hong Kong. Government offers land to private developer who is the highest bidder for a 75-year-or–longer land rental period at each auction. Peng and Wheaton found that under normal supply scheme, both prices and completion of housing would increase stably; under restrictive strategy, quantity of land and housing supply fall and housing prices rise.



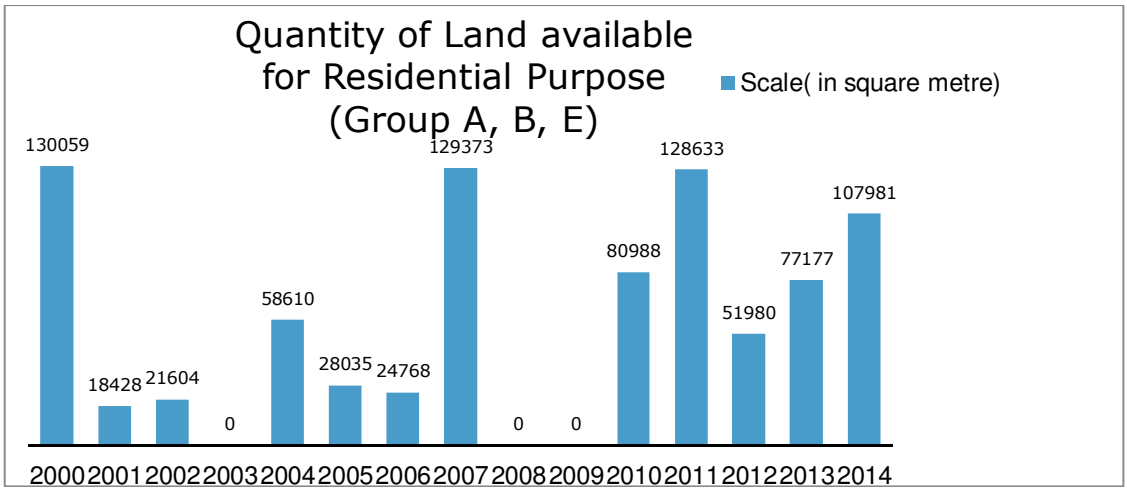
Results: By R-Software

```
Call:
lm(formula = PP ~ LSF)
Residuals:
    Min      1Q  Median      3Q     Max
-2953.1 -1609.6  -117.2  1000.4  2768.3
Coefficients:
             Estimate   Std. Error  t value  Pr(>|t|)
(Intercept) 5.040e+03 8.255e+02   6.105   7.68e-05 ***
LSF         2.244e-02  1.163e-02   1.929   0.0799 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 1904 on 11 degrees of freedom
Multiple R-squared:  0.2528,
Adjusted R-squared:  0.1849

F-statistic: 3.722 on 1 and 11 DF,  p-value: 0.07988
```

Graph 11: Property Prices (PP) versus Land Supply Figure (LSF)

Empirical observation shows that there is no strong co-relationship between Property Prices (PP) and Land Supply Figure (LSF). Testing using R software also shows that Property Price (PP) is weakly correlated to Land Supply Figure (LSF). Increasing per unit of LSF increases 2.244e-02 PP.

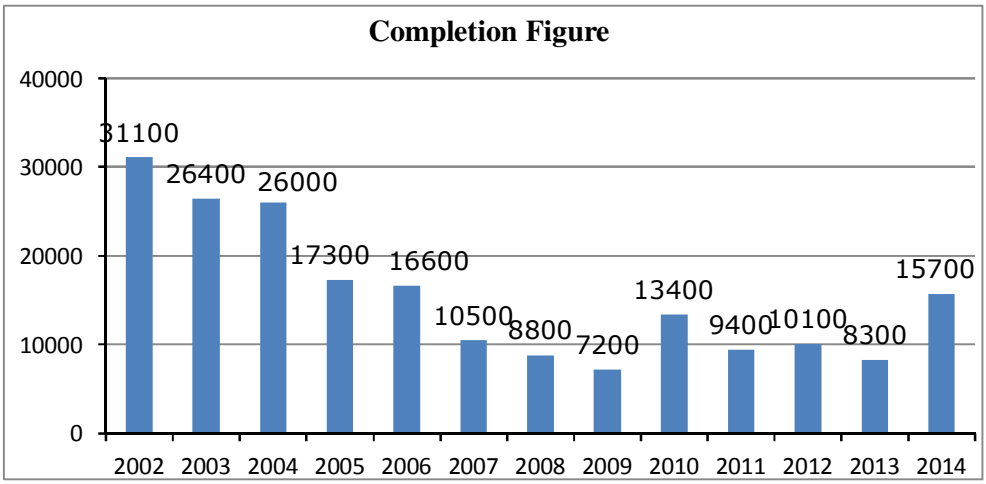


Graph 12: Supply of Land Figure (LSF) between year 2000 and 2014
(Source: Lands Department of Hong Kong)

Result of linear regression test shows that there is little correlation between land supply figure (LSF) and transaction price (PP) based on the pattern of linear regression graph. It cannot contribute to any impact on the determination of transaction price.

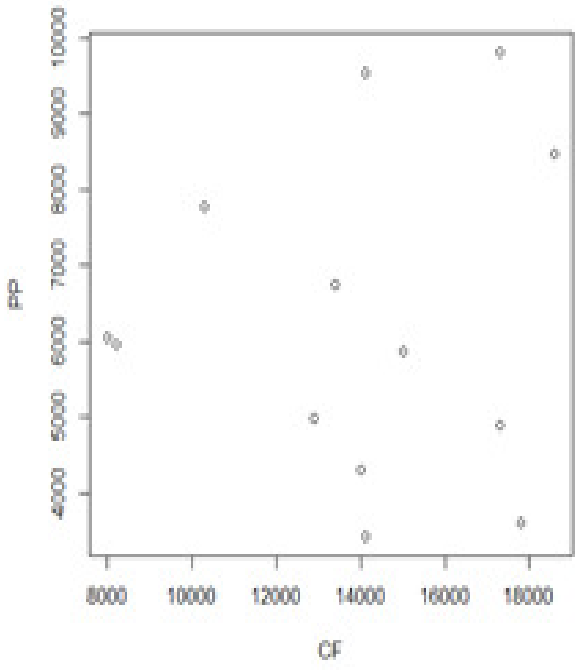
VIII. Completion Figure of Private Housing (HCF)

According to Alice, Y. Y. Cheung (1996), land use and planning by the government affect the land supply in Hong Kong. Since developers take several years to build flats from construction to available for sales, housing completion figure is a leading indicator of the private housing quantity supply in the future.



(Source: Transport and Housing Bureau)

Graph 13: Hong Kong's Housing Completion Figure (HCF) between year 2002 and 2014.



Results: By R-Software

Call:
lm(formula = PP ~ HCF)

Residuals:

Min	1Q	Median	3Q	Max
-2142.3	-1161.3	-78.4	444.6	3590.7

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	8975.76585	1054.84291	8.509	3.62e-06 ***
HCF	-0.17557	0.06138	-2.861	0.0155 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1668 on 11 degrees of freedom
Multiple R-squared: 0.4266,
Adjusted R-squared: 0.3744
F-statistic: 8.183 on 1 and 11 DF, p-value: 0.0155

Graph 14: Property Prices (PP) versus Completion Figure of Private Housing (HCF)

Empirical data shows that there is no strong co-relationship between Property Prices (PP) and Completion Figure of Private Housing (HCF). Empirical testing using R-software shows that Property price (PP) is inversely proportional to the Housing Completion Figure (HCF). In-

creasing per unit of HCF decreases 0.17557 PP. It reveals that transaction price (PP) goes down with the increase of annual completion figure (HCF).

Data Collection

Data collection on independent explanatory variables include real interest rate (RIR), gross domestic product per capita (GDPPC), affordability index (AI), private domestic rental index (PDRI), transaction volume (TV), land supply figure (LSF), and completion figure of private housing (HCF) with dependent variable being Property Price (PP). Data will be collected from the Rating and Valuation Department, Market Statistics Department, Centadata, and Trading Economics between the year 2002 and 2014.

YEAR	PP	RIR	GPCPC	AI	LSF	HCF	PDRI	TV
2002	3610	2.7	20757.66	0.228	21604.2	31100	81.3	5767.3846
2003	3430	3.7	22152.25	0.207	0	26400	72.8	5659.9231
2004	4310	2.9	22112.93	0.277	58610	26000	75.5	7894.9231
2005	5860	2.9	22379.95	0.354	28035	17300	83.3	8105.1538
2006	4900	2.3	23109.52	0.374	24768	16600	90.1	6498.3077
2007	4990	2.5	24924.92	0.368	129373	10500	100.5	9660.1538
2008	6040	1.7	26649.75	0.359	0	8800	113.2	7533.7692
2009	5960	1.4	28341.31	0.354	0	7200	102	9007.7692
2010	6740	1.7	29915.25	0.4	80988	13400	120.7	10599.0769
2011	7770	1	30369.59	0.437	128632.7	9400	137.1	6651.7692
2012	8470	1.3	29559.05	0.452	51980.3	10100	149.6	6411.1538
2013	9540	3.6	31328.59	0.512	77177.2	8300	163.6	4053
2014	9810	-2.5	32607.96	0.502	107981.4	15700	171.8	5061.1538

Table 1: Data collection between year 2002 and 2014

Coefficient Correlations[a]

Model			PDRI	TV	LS	HCF	RIR	AI	GDPPC
1	Correlations	PDRI	1.000	.465	.226	-.420	.700	-.192	-.173
		TV	.465	1.000	-.236	.303	.253	-.103	.103
		LS	.226	-.236	1.000	-.577	.507	-.282	.069
		HCF	-.420	.303	-.577	1.000	-.625	.038	.287
		RIR	.700	.253	.507	-.625	1.000	-.135	-.076
		AI	-.192	-.103	-.282	.038	-.135	1.000	-.886
		GDPPC	-.173	.103	.069	.287	-.076	-.886	1.000
	Covariances	PDRI	464.314	1.275	.026	-.487	229872.309	-54449.566	-47738.801
		TV	1.275	.016	.000	.002	490.302	-172.767	167.471
		LS	.026	.000	2.885E-5	.000	41.549	-19.983	4.716
		HCF	-.487	.002	.000	.003	-511.632	27.153	197.152
		RIR	229872.309	490.302	41.549	-511.632	232479833.9	-27193089.3	-14866153.4
		AI	-54449.566	-172.767	-19.983	27.153	-27193089.3	174052096.8	-149662387
		GDPPC	-47738.801	167.471	4.716	197.152	-14866153.4	-149662387	163937033.0

a. Dependent Variable: AP

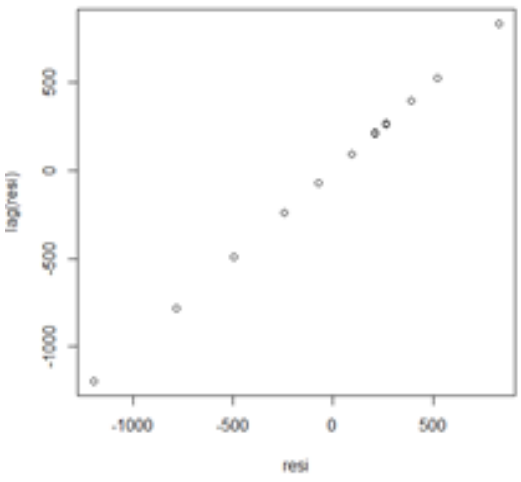
Table 2: Multi -collinearity Test results

Revised hypothesis

Two sets of data, Real Interest Rate (RIR) and Private Domestic Rental Index (PDRI) as well as a GDP Per Capita (GDPPC) and Affordability Index (AI) are found to be highly correlated with correlation coefficients of 0.7 and -0.886 respectively. We shall abandon Private Domestic Rental Index (PDRI) and GDP Per Capita (GDPPC) in the hypothesis. The hypothesis is revised to :

$$Y(PP)_t = a + b\,X_1(RIR)_{t-1} + c\,X_2(AI)_{t-1} + d\,X_3(LSF)_{t-1} + e\,X_4(HCF)_{t-1} + f\,X_5(TV)_{t-1} + \varepsilon$$

Data are then input into the hypothesis using R software with results shown below:



Results: By R-Software

Call:
lm(formula = PP ~ RIR + AI + LSF + TV + HCF)

Residuals:

Min	1Q	Median	3Q	Max
-1193.5	-240.9	209.6	263.4	830.0

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	1.055e+03	3.727e+03	0.283	0.785
RIR	-1.637e+02	1.128e+02	-1.452	0.190
AI	1.756e+04	5.859e+03	2.997	0.020 *
LSF	-4.140e-03	6.558e-03	-0.631	0.548
TV	-1.067e-01	1.540e-01	-0.693	0.511
HCF	3.776e-02	5.811e-02	0.650	0.537

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 726.7 on 5 degrees of freedom
Multiple R-squared: 0.9307,
Adjusted R-squared: 0.8812
F-statistic: 18.81 on 5 DF, p-value: 0.0006254

Graph 15: Log (Resi) versus Resi

R2 represents the fraction of the sample variation of the y values (measured by SS_{yy}) that is explained by the least squares prediction equation. Thus, R2=0 implies a complete lack of fit

of the model to the data, and R2=1 implies a perfect fit with the model passing through every data point. In general, the larger the value of R2, the better the model fits the data. Our R2=0.9307 implies a good fit of this model.

IX. Conclusions

(1) In the linear multiple regression model, property Price (PP) is expressed in terms of five independent explanatory variables - real interest rate (RIR), affordability Index (AI), Land Supply Figure (LSF) , Housing Completion Figure (HCF) and Transaction Volume (TV). By using SPSS. Results show that the R^2 and adjusted R^2 of 0.9639 and 0.8812 respectively.

(2) Affordability Index (AI) and Housing Completion Figure (HCF) have positive impacts on Property Price (PP). Out of which, Affordability Index (AI) has the largest effect on Property Price (PP) while Housing Completion Figure (HCF) has the least impact on Property Price (PP).

(3) Real Interest Rate (RIR), Land Supply Figure (LSF) and Transaction Volume (TV) have negative impact on Property Price (PP) with Transaction Volume (TV) having greatest impacts on Property Price (PP).

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