School of Economics

L13500 Economics Dissertation

Title: Determinants of Housing Prices in Hong Kong

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Word Count: 6907

This Dissertation is presented in part fulfilment of the requirement for the completion of an undergraduate degree in the School of Economics, University of Nottingham. The work is the sole responsibility of the candidate.

Abstract

This dissertation uses a Vector Error Correction Model of Hong Kong housing prices to investigate whether the high prices are driven by fundamental macroeconomic variables. Real interest rate has the strongest long-run effect on the housing prices. Construction cost and land supply have weaker long-run effects on the housing prices. The long-run effect of real per capita income is statistically insignificant. The housing prices respond positively to shocks of real per capita income and domestic credit, but respond negatively to shocks of real interest rate and construction cost. The response of the house prices to land supply is insignificant. The VECM also forecasts a rising trend of the housing prices. Policy makers should take into account the long and short run effects of the macroeconomic variables when designing housing policies to alleviate the housing problem. Despite the significant estimation results, model issues that can be corrected to enhance the results are discussed.

Introduction

This dissertation uses a Vector Error Correction Model of Hong Kong housing prices to investigate whether the high prices are driven by fundamental macroeconomic variables. The variables incorporated in the model of the housing prices are real per capita GDP, land supply, construction cost, real interest rate and real domestic credit. The model is used to examine their long run and short run effects on the housing prices.

A co-integration estimation methodology, which is a widely used method to study non-stationary time series, is employed. Unit root test results show that housing prices, real per capita GDP, land supply, construction cost, real interest rate and real domestic credit are non-stationary, and that their first differences are stationary. Hence, a co-integration methodology

is necessary. Instead of using the Engle Granger two-step approach for co-integration, a vector error correction model (VECM) is used due to the fact that it treats all the variables in the system are endogenous, which is often the case for macroeconomic variables. An optimal lag order of 3 for the VECM is confirmed. A single co-integrating vector is identified, producing a single co-integration equation, which depicts the long-run relationships among the variables. Diagrammatic impulse response functions are presented to show the short-run dynamics of the variables.

For the estimated long-run effects, real interest rate has the strongest long run effect on the housing prices. Construction cost and land supply with a 5-quarter lag have relatively weaker long-run effects on the housing prices. The effects of real per capita GDP and real domestic credit are statistically insignificant. The VECM forecast shows that the house price index will continue to rise from 2016Q3 to 2020Q3. For the estimated short-run dynamics, the responses of house prices to a unit shock of per capita income and domestic credit are positive; the responses to a unit shock of construction cost and real interest rate are negative. The response to a unit shock of land supply is insignificant. The adjustments of house prices to the equilibrium after those shocks are slow.

As the Federal Reserve has started a new phase of monetary policy regarding interest rate hikes, interest rates in Hong Kong are going to follow the same path. Hypothetically, if housing bubble does exist in the housing market of Hong Kong, increases in interest rates will lead to a collapse of the bubble. Policy makers in Hong Kong should respond accordingly by introducing monetary, fiscal and housing policies that can alleviate the consequences of a possible bubble collapse.

Literature Review

Instead of starting with a specific case study of property prices, a cross-country study is used as a starting point for the investigation. Glindro, Subhanji, Szeto and Zhu (2011) provide an empirical analysis of house prices determinants in nine Asia-Pacific economies during 1993-2006. It deploys the error correction framework used by Capozza et al. (2002). The framework consists of three stages: estimating the long run relationship, estimating an adjustment relationship and allowing serial correlation and mean reversion coefficients to vary over time. Quarterly data of residential property prices are used in the analysis. Variables used in the analysis include real GDP, population, construction cost index, land supply index, real mortgage rates, real effective exchange rates, stock price index, and four institutional indices. Glindro, Subhanji, Szeto and Zhu (2011) then study long-term and short-term determinants using the error correction framework. The panel regression results suggest that the patterns of national housing prices dynamics show cross-country heterogeneity. The differences in land supply and business environments across the countries are used to explain the heterogeneous patterns. Glindro, Subhanji, Szeto and Zhu (2011) also find little evidence of housing bubbles in the nine economies because the prices mainly reflected adjustments to better economic fundamentals. The paper provides a starting point for a study in housing prices determinants in a specific Asian economy, such as Hong Kong, because some of the variables can be deployed in the study. However, panel regression is performed in the paper, so it may not be applicable to a study in Hong Kong in which time-series data are used instead.

Peng (2002) uses a model in which standard fundamental factors and a bubble builder and burster term are incorporated to study how housing prices were affected by the variables from 1981-2002. The model was developed by Abraham and Hendershott (1996). It expresses growth in the fundamental real property price as a linear function of demand and supply variables: change in unemployment rate, real interest rate, changes in real rental index, in number of households adjusted for public housing and in the private housing stock. The actual growth in property prices is modelled as the above fundamental value plus an error term. The error term is expressed as a linear function of the fundamental price in the previous period and actual real prices in the previous period. By combining the above three linear equations, estimations are performed. The estimation results of Peng (2002) suggest that the signs of all the coefficients are correct and significant, implying that the fundamental factors contributed to the changes in property prices during the time period. Moreover, the results also show that the bubble builder, with a coefficient of 0.32, and the burster, with a coefficient of 0.06, lie between the ranges suggested in the study of Abraham and Hendershott (1996). Therefore, Peng (2002) concludes that Hong Kong property prices were affected by speculations. This paper manages to model the elements of bubble in the context of Hong Kong and provides insights into the health of Hong Kong property market during the period. However, the paper did not include a variable to capture the effect of credits. Buyers may need mortgages to finance home purchases when they lack funds to pay in full. Neglecting the mortgage credit in the model might imply that buyers during the period could purchase property in full, which could lead to bias.

Leung, Chow and Han (2008) and Craig and Hua (2011) both use a co-integration estimation methodology to study the long-run and short-run determinants of housing prices in Hong Kong. Using this method, the long-run relationship among housing prices and the variables is

estimated, and subsequently the short-run dynamic relationship is estimated using an error correction equation. The two papers differ from each other by having different purposes. Leung, Chow and Han (2008) focus on graphical and clustering analyses of six property markets in Hong Kong, while Craig and Hua (2011) focus on the effectiveness of the government policies in controlling rising property prices. The two papers share common macroeconomic variables in the models: real GDP per capita, real interest rate and land supply. However, Leung, Chow and Han (2008) also include residential investment inflator in the long-run and short-run analyses to capture the inflation hedging and cost channels and the impact of real construction cost. Lag of housing prices and Hang Index are used in the short-run analysis. The former one is used to capture the effect of back-ward looking expectations on property prices, whereas the latter one is used to capture the wealth effect from rising equity prices and the effect of market expectations on economic outlook. Craig and Hua (2011) use real construction index and real domestic credit in the long-run analysis, and include four stationary policy variables in the short-run analysis to assess the effectiveness of the government policies in controlling property prices. Leung, Chow and Han (2008) find that the real GDP per capita, real interest rate, land supply and residential investment deflator are the long-run determinants, and that equity price and lag of property price also affect property prices in the short-run. Moreover, Craig and Hua (2011) find that the real GDP per capita has the most robust long-run effect on property prices followed by the land supply, real interest rate and real construction cost, and that the real domestic credit has the weakest effect. The insignificance of the real domestic credit to the changes in property prices is supported by Gerlach and Peng (2005), who suggest that property prices are not influenced by bank lending. Leung, Chow and Han (2008) and Craig and Hua (2011) have provided a foundation on which this dissertation can be built. Real mortgage credit will be included in the econometric analysis, because the surging trends of Hong Kong property

price imply that buyers may need mortgages to finance their house purchases, but the variable will be tested whether it is non-stationary, which is necessary for co-integration to exist among the variables. Moreover, the dissertation will cover data from 2012-2016, during which the property prices in Hong Kong have reached to the world's least affordable level.

Panagiotidis and Printzis (2016) use a Vector-Error Correction Model approach to explain macroeconomic determinants of housing prices. This approach defers from the Engle Granger two-step approach in the sense that it can be used to investigate long-run equilibrium equations with more than one co-integrating vector. The number of co-integrating vectors determines the number of co-integrating equations. In theory, the Engle-Granger 2 step approach is restricted to deal with two variables equation (Engle and Granger, 1987), which entail a maximum of one co-integrating vector. However, VECM, which is fundamentally a VAR model, treats all variables in the system as endogenous variables, meaning that they interact with each other, whereas the Engle-Granger approach uses OLS to estimate how a dependable variable is affected. If more than one-integrating vector is identified, there are more than one long-run relationship among the variables, therefore, a difficulty arises when using a VECM to investigate how the "dependent" variable is influenced. Panagiotidis and Printzis (2016) study the economic fundamentals of the Greek housing market. A VECM is employed to study both the short run and long run dynamics. Causality tests are performed to study the directions of causality between the housing prices and the economic variables. Dynamic relationships are investigated using variance decomposition and impulse response functions. Consumer Price Index, Industrial Production Index, retail trade volume, interest rate, growth rate of mortgages, growth rate of money supply and unemployment rate are found statistically significant in the long-run relationship with positive coefficients. The house price index responds to shocks of mortgage growth rate, Consumer Price Index and

retail volume and returns to long-run equilibrium after 36 months. (Panagiotidis and Printzis, 2016) Moreover, STATA has a set of in-built commands for VECM estimation, from VECM specification to estimation results, which is easy for ones without prior programing knowledge to use. Using Engle-Granger 2 step approach on STATA requires additional STATA modules and statistical techniques, which can be far beyond the scope of the dissertation. In the light of the advantages of VECM, it will be used to investigate long-run relationships among variables and impulse responses of the housing prices.

An Overview of the Hong Kong Economy and Housing Market

Hong Kong is well known for its status as one of the three major financial centres in the world, alongside New York and London. The Stock Exchange of Hong Kong has been a preferred listing platform for Chinese and foreign companies. Hong Kong is also renowned for its friendly business environment which is supported by low tax rates, sound financial and legal infrastructure and pro-business policies. The Hong Kong government has adopted positive non-interventionism, which is a core economic policy of Hong Kong first introduced by Sir John Cowperthwaite, the Financial Secretary of British Hong Kong from 1961 to 1971. Hong Kong is an example of free market economy. The following figures summarise the macroeconomic conditions of Hong Kong over the two decades.

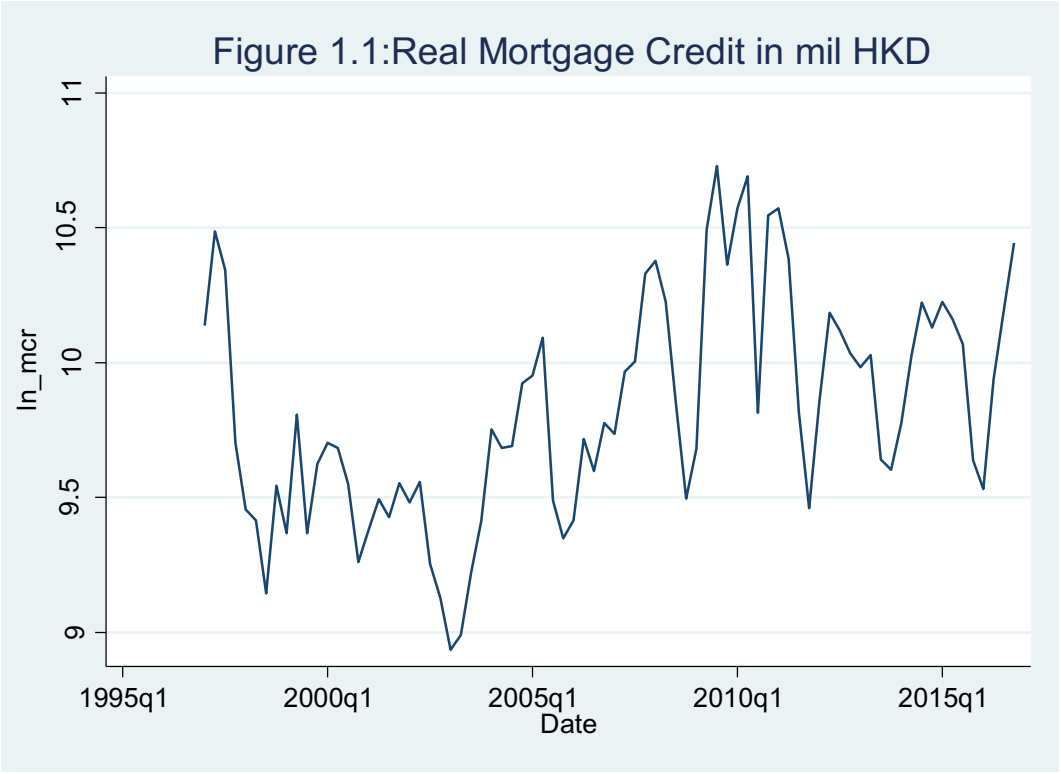


Figure 1.1:Real Mortgage Credit in mil HKD
ln_mcr
9
9.5
10
10.5
11
1995q1
2000q1
2005q1
2010q1
2015q1
Date

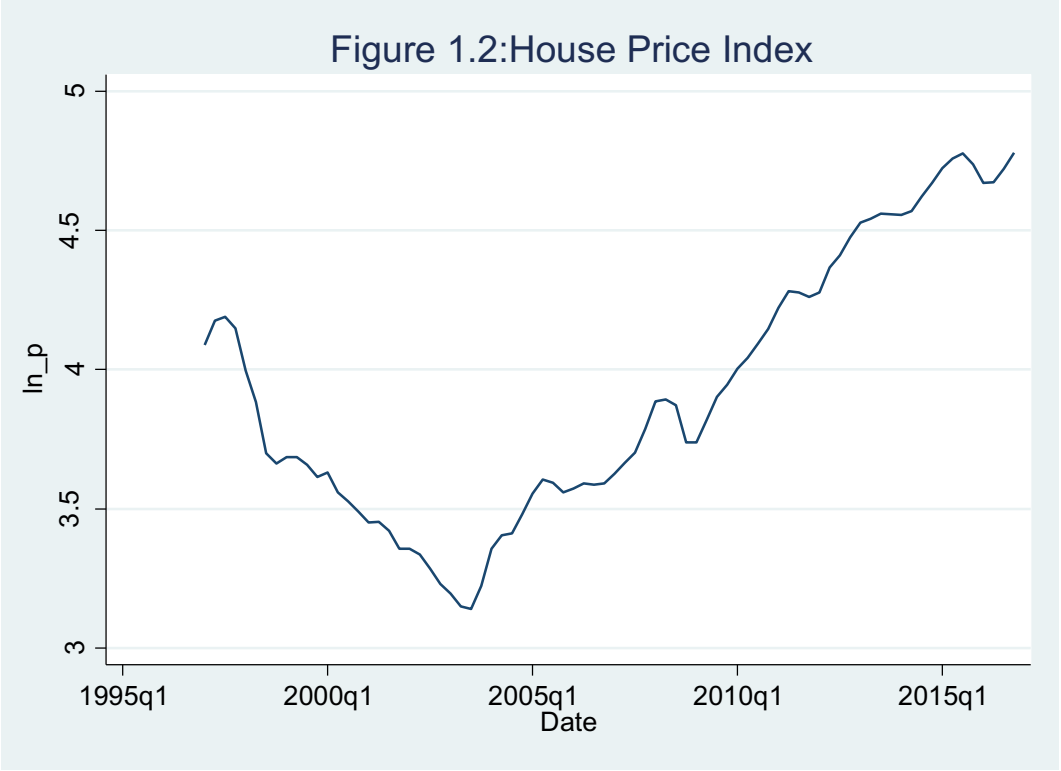


Figure 1.2:House Price Index
ln_p
3
3.5
4
4.5
5
1995q1
2000q1
2005q1
2010q1
2015q1
Date

Figure 1.3:Real GDP per Capita in HK$1000

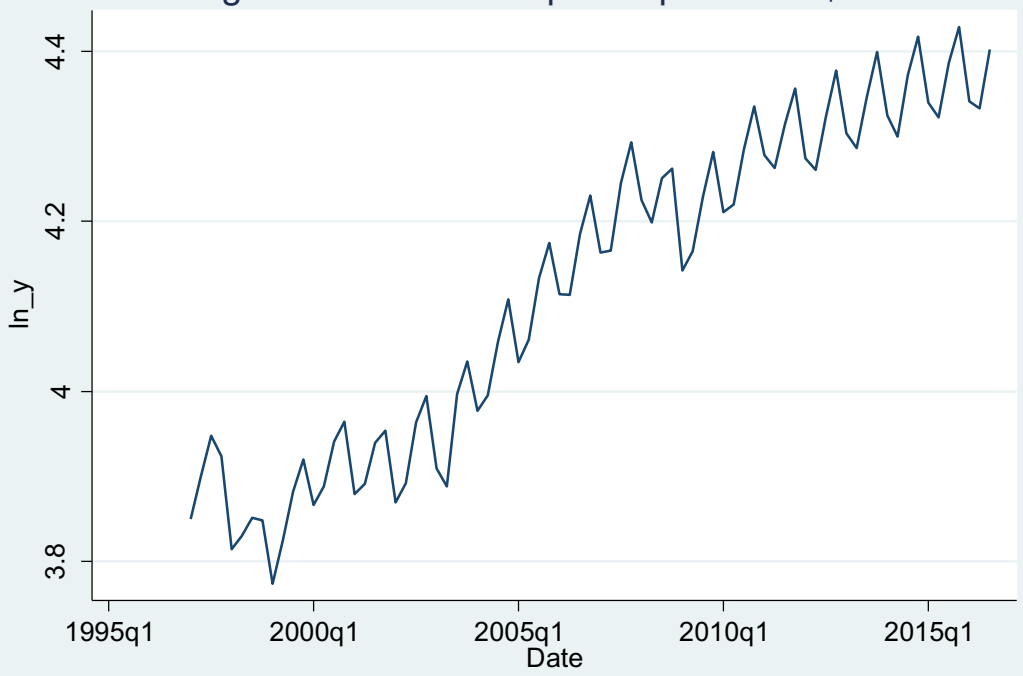


Figure 1.4:Real Construction Cost Index

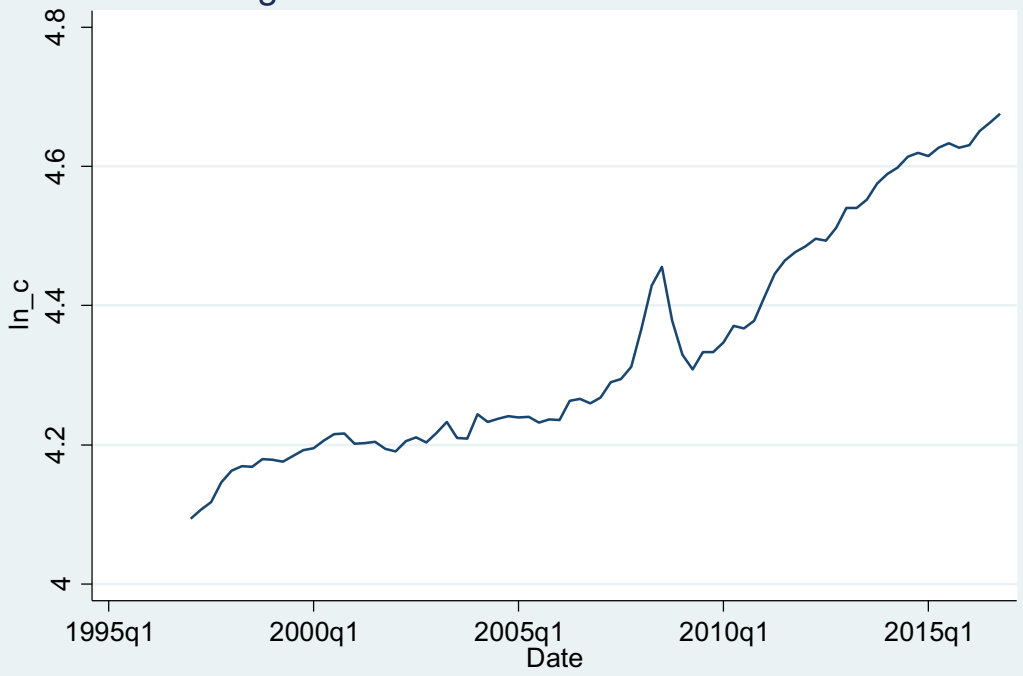
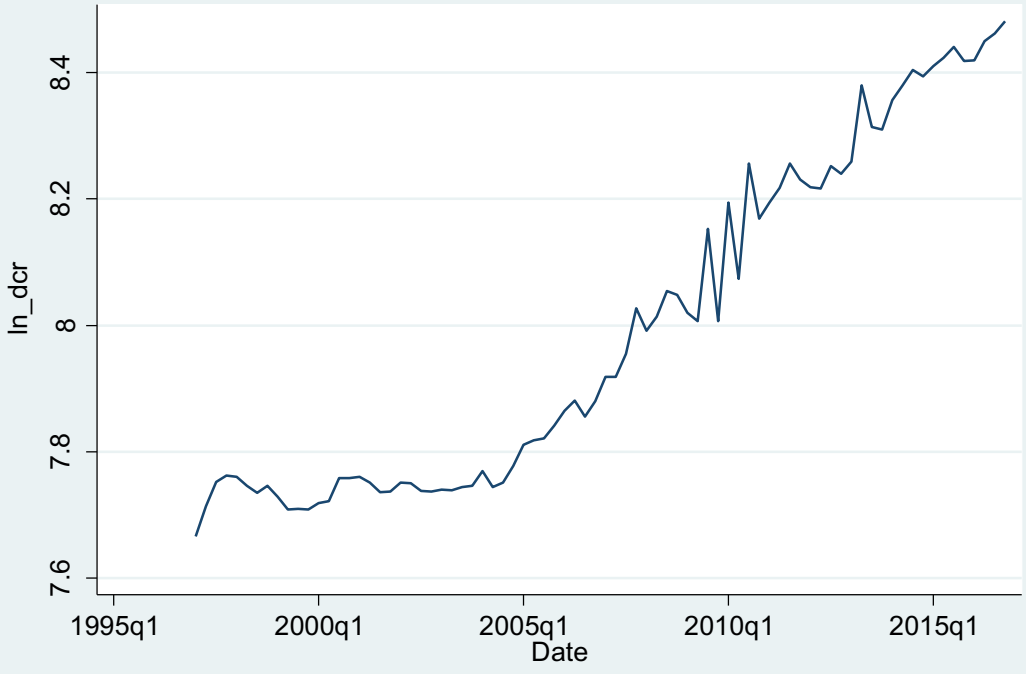
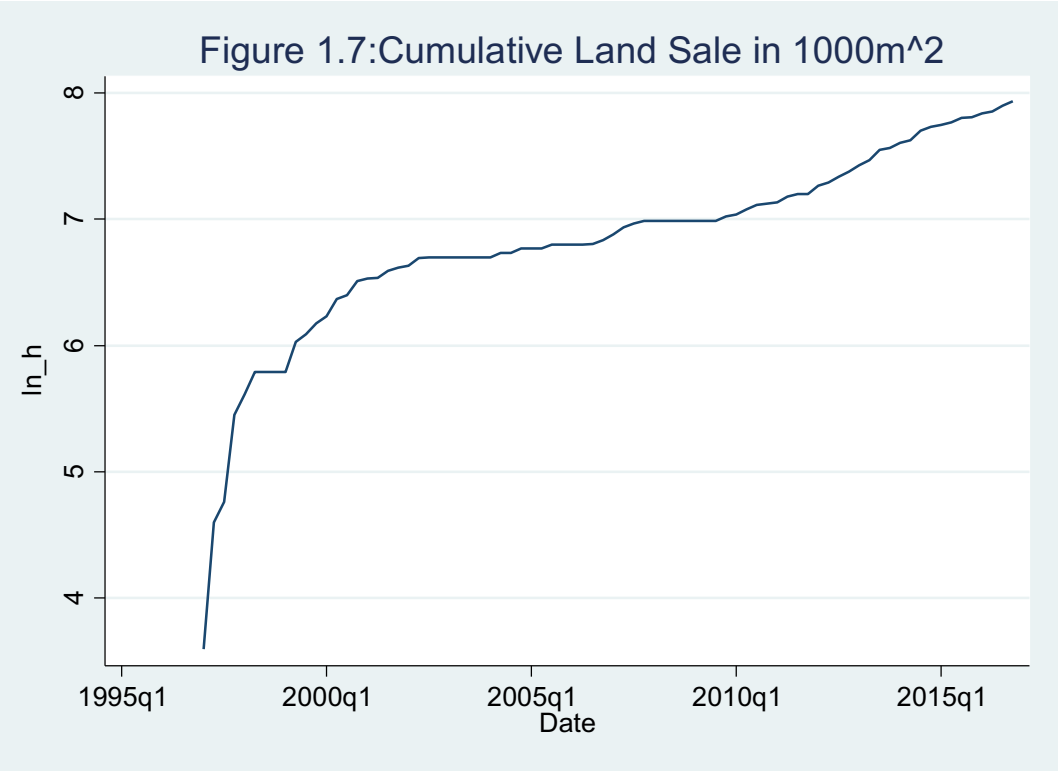


Figure 1.5:Real Interest Rate %PA

Figure 1.6:Real Domestic Credit in HK





Another distinct feature of the Hong Kong economy is its currency peg to the U.S dollar. Due to the currency link, Hong Kong's monetary autonomy is not complete. For example, an increase in U.S. inter-bank lending rate can force the Hong Kong Monetary Authority, the central bank of Hong Kong, to follow the increase because not doing so may induce aggressive arbitrage, causing the HKD to USD exchange rate to deviate from the floating range. Hong Kong's close relationship with China in terms of trade and investment is also a key feature of its economy. Hong Kong has been the preferred platform for Chinese enterprises to invest abroad due to its sound financial and legal infrastructure and free market policies. Hong Kong has taken this advantage to grow for some decades, and as China becomes more connected to the world in terms of trade and investment, Hong Kong further benefit from its close relationship with China.

Despite the robust economy of Hong Kong, an overwhelming housing problem has frustrated the region for nearly a decade. Houses have become highly unaffordable since 2004(IMF, rising too fast), and the level of unaffordability reached the highest in the world: the median price of a housing unit was 18.1 times the median annual pre-tax income in 2016 (Demographia, 2017). Figure 1.2 shows the trend of house price index in Hong Kong. The increasing trend of house price index is likely to continue. The frustration has pressed the government to curb the escalating prices. An aggressive housing policy has recently been implemented to cool down the housing market: raising the stamp duty for second-home buyers to 15%, although at the moment they failed. Even with the aggressive housing policy to cool down the housing market, the housing prices still have the momentum to rise further. This has aroused the author's interest in investigating the driving forces of the housing prices.

A Vector Error Correction Model of Hong Kong Housing Prices

Variables and Data

A reduced form model of housing prices in which demand-side and supply-side factors of property market are incorporated is employed. Leung, Chow and Han (2008) and Craig and Hua (2011) provided a foundation on which the model is built. Housing price (p), which is expressed in in terms of house price index, is the variable of main interest: the model focuses on how the variables influence house prices. The evolution of housing prices can be studied using demand and supply factors, in the same manner as studying goods and services (Peng, 2002). Despite residential property being a commodity and an investment asset, due to the scope of the dissertation, the econometric specification assumes it is only a commodity. This can allow simplification of the model, as factors regarding its nature of being an investment asset are not considered.

The demand-side variables are income (y), real interest rate (r) and bank credit (dcr). Income growth is generally believed as one of the fundamental drivers of house prices. An increase in income, in the form of labour income, is expected to raise the housing affordability of people. From 1.2 and 1.3, the real per capita GDP grows steadily over the past 20 years, but the house prices decrease in the periods between 1997 and 2004 and keep increasing from 2004 until now. In theory, real interest rate is expected to have a negative effect on house prices. An increase in real interest rates is caused by an increase in nominal interest rates relative to inflation, which will increase the borrowing cost in real terms, causing a decrease in demand for home purchases. Bank credit reflects the liquidity conditions of the Hong Kong financial system. Housing purchases are often funded by mortgages, so a financial system with high liquidity can enhance housing purchases.

The supply-side variables are house supply (h) and construction cost (c). Reduced land supply is believed to be one of the main causes of the recent house price upsurge (Leung, Chow and Han, 2008). In the face of increasing housing demand driven by higher income and low nominal interest rates, a reduction in land supply bolsters the rising trend of housing prices. Construction cost is faced by housing developers, but is transferred to house buyers at the end. An increase in construction causes an increase in housing prices, although the effect is expected to be not significant.

Quarterly data from 1997Q1- 2016Q4 are used in the analysis. Housing prices are expressed in terms of house price indices which cover all classes of residential property. Quarterly house price indices are collected from the Rating and Valuation Department of the HKSAR. Cumulative land sale at land auctions is used as a proxy of house supply. Although

completion of units is a better proxy of land supply, the data are only available in annual basis and transforming them to quarterly data can lead to multicollinearity. So, square meters of land sold for residential purpose are collected from the Land Department of the HKSAR. Construction cost indices are used as a proxy of construction cost. Monthly construction cost indices are collected from the Civil Engineering and Development Department of the HKSAR and are transformed to quarterly data by averaging, which is a widely used method. Both domestic credit and mortgage credit are reasonable choices for the proxy of bank credit. Both monthly domestic credit and monthly mortgage credit are collected from the Hong Kong Monetary Authority, and are transformed to quarterly data and are expressed in real terms. Domestic credit is chosen at last because the augmented Dickey-Fuller test confirms its non-stationarity, which is necessary for co-integration analysis. Best lending rate is used as a proxy of real interest rate because it reflects the interest rates faced by households. The quarterly data of it are collected from the Hong Kong Monetary Authority and are expressed in real terms. Real GDP per capita is computed by dividing real GDP by total population of Hong Kong. They are collected from the Hong Kong Monetary Authority and the Census and Statistics Department of HKSAR.

Unit Root Test Analysis

Having decided the variables to be included in the model, a unit root test analysis is followed. The unit root tests are used to test whether the variables have a unit root or not. This is a standard and important procedure when studying time-series data, as treating time-series data with improper models lead to misspecifications. VARs can be well applied to stationary time series in which no unit root is present, but fail to perform when applied to non-stationary time series in which unit roots are present. Granger and Newbold (1974) illustrate this by showing

that regressing two independent random walk processes can yield significant results despite the fact that they are not related. Augmented Dickey-Fuller tests, which include lagged changes in the tests (Dickey and Fuller, 1981), are used to determine the presence of unit root in a series. The null hypothesis of the test is that the variable has a unit root. The unit root test results are present in table 2. All the variables are found to have a unit root as the null hypotheses cannot be rejected at 1%, 5% and 10% significance. But their first differences are not found to have a unit root at 1% significance level, suggesting that the variables are non-stationary on levels, but stationary in differences. Therefore, all the variables are I(1).

Table 2

Unit Root Test Results(Augmented Dickey-Fuller Test)

	Lag	Level	First Difference	I(K)
Log(house price index)	0	-2.719	-4.321***	1
Log(real per capita GDP)	0	-1.281	-8.844***	1
Log(land supply)	5	-2.494	-5.033***	1
Log(construction cost index)	0	-1.372	-6.023***	1
Real Interest Rate	0	-1.458	-7.016***	1
Log(real domestic credit)	0	-2.884	-19.641***	1

(1) Null hypothesis: variable has a unit root

(2) *** 1% significance, ** 5% significance and * 10% significance

Optimal Lag Order Determination

Even though in reality unit roots are present in a wide range of macroeconomic time series, they can still be econometrically meaningful and significant if they are co-integrated. Individually non-stationary variables are said to be co-integrated, if a linear combination of them is stationary (Engle and Granger, 1987). In a multivariate context, non-stationary time series can be treated with a VAR containing non-stationary variables, or namely a VECM.

The next step of establishing the VECM is to determine the optimal lag order of the model. In general, selecting a lag order is not a science: one cannot determine an optimal lag following a fixed rule. Therefore, existing theories and usual practices are taken into account when deciding the optimal lag order. In-built commands in STATA are used to determine the optimal lag order for the VECM based on the Akaike information criterion, Hannan-Quinn information criterion and Bayesian information criterion. Moreover, the maximum lag order is set to eight. This takes into account the fact that including too many lags leads to higher mean square forecast errors and that including too few leads to autocorrelation of residuals. The results shown on table 3 determine the optimal lag order, which is three. The results are generated using STATA.

Table 3

Identification of optimal lag order

Lag	AIC	HQIC	SBIC
1	-3.2949	-3.20619	-3.07182
2	-3.58966	-3.48828	-3.33471
3	-3.65706*	-3.54301*	-3.37025*
4	-3.6289	-3.50217	-3.31022
5	-3.60542	-3.46602	-3.25487
6	-3.57789	-3.42581	-3.19546
7	-3.5826	-3.41784	-3.1683
8	-3.56858	-3.39116	-3.12242

(1) *Optimal lag order

Identification of Co-integrating Vector

A co-integration relationship exists among variables, if a linear combination of individually non-stationary variables is found to be stationary. In the presence of co-integration of the variables, the long-run relationships of and the short run dynamics of the model can be estimated. The concept of co-integration can be illustrated with a hypothetical equilibrium equation: $z_t = \beta_0 + \beta_1 x_t + e_t \quad (eq.1)$, in which both y_t and x_t are assumed I(1) and e_t is

stationary disturbance term. Rearranging eq.1, $e_t = z_t - \beta_0 - \beta_1 x_t \ \ (eq.2)$ is obtained. Since e_t is stationary, the left hand side of eq.2, a linear combination of z_t and x_t, is also stationary. This simple example illustrates that for equilibrium relationships involving non-stationary variables to hold, the existence of a stationary combination of the variables is necessary (Enders, 2014). For co-integration to exist, in theory, there should exist a co-integrating vector is a vector $\beta = (\beta_1, \beta_2, \dots, \beta_k)$ such that the linear combination $\beta x_t = \beta_1 x_{1t} + \beta_2 x_{2t} + \cdots + \beta_k x_{kt}$ is integrated (Engle and Granger, 1987). There are two main methods of identifying co-integration: the Engle-Granger 2 step procedure (1987), which tests for the stationarity of predicted residuals of an equilibrium relationship, and the Johansen procedure (1988), which estimates co-integrating rank using maximum likelihood estimators. The latter is more suitable than the former, because it can also test and estimate for the presence of more than one co-integrating vector while the former cannot (Enders, 2014). For a linear combination of k variables, there exists at most k-1 co-integrating vectors, so there may exist at most 6-1 = 5 co-integrating vectors in this multivariate context. Therefore, using the Johansen procedure for the VECM is a reasonable option.

The Johansen test consists of two forms: the trace test and maximum eigenvalue test, and both examine the number of co-integrating equations (Johansen, 1988). For the former, the null hypothesis is that the number of co-integrating equations equals to a given value, and the alternative hypothesis is that the number of co-integrating equations is greater than the give value. For the latter, the null hypothesis is the same as the former, and the alternative hypothesis is that there exists one more co-integrating equation than the given value. Rejecting the null hypothesis in any of the two tests suggests that co-integration exists, but the number of co-integration equations needs to be further examined with different given values. Using STATA's in-built commands, the Johansen test is performed and the results are

shown in table 4. One co-integrating rank is identified, which represents a single co-integrating vector in the system, therefore a single co-integrating equation in the VECM.

Table 4

Johansen test for co-integration at lag order (3)

Rank	Eigenvalue	Trace Statistics
0	.	118.9501
1	0.53467	64.6338*
2	0.31114	38.1713
3	0.20962	21.4696
4	0.1584	9.2257
5	0.09259	2.3269
6	0.03224	.

(1) *Number of co-integrating vectors identified

Results

Having specified the Vector Error Correction Model, the model can be deployed to estimate the long-run relationship among and short run dynamics of the variables. The long-run relationship of the model is represented by a co-integrating equation, and the dynamics of the variables are illustrated by graphs of impulse response functions. Diagnostics tests are presented at the end to assess the reliability of the results.

The long-run relationship among the variables is represented by the co-integrating equation shown in figure 2.1, and the coefficients are shown in table 5. The co-integrating equation fluctuates around a mean slightly above zero. In theory, an equilibrium can be regarded as a stationary point which is influenced by forces that have the tendency to move the system back to equilibrium when it deviates from the equilibrium (Engle and Granger, 1987). Granger (1981) introduce a term called co-integration, which is a condition for variables with

long-run components to follow equilibrium properties while short-run components also play a role in dynamic specification. In other words, if co-integration is found among variables, there exists a long-run equilibrium relationship among them. A single co-integrating vector has been identified in the VECM using the Johansen test, suggesting a long-run relationship among the variables.

$$p_t^{\square} = -9.414 + 0.300y_t - 0.943h_{t-5} + 4.289873c_t - 0.094r_t + 0.0436dcr_t \text{ (eq.3)}$$

The long-run relationship between house price index, real per capita GDP, house supply, construction cost index, real interest rate and real domestic credit for one co-integrating vector in the period 1997-2016 is presented in eq.3. The standard errors are presented in table 5. The variables are in logs except for real interest rate.

Figure 2.1:Co-integrating Equation

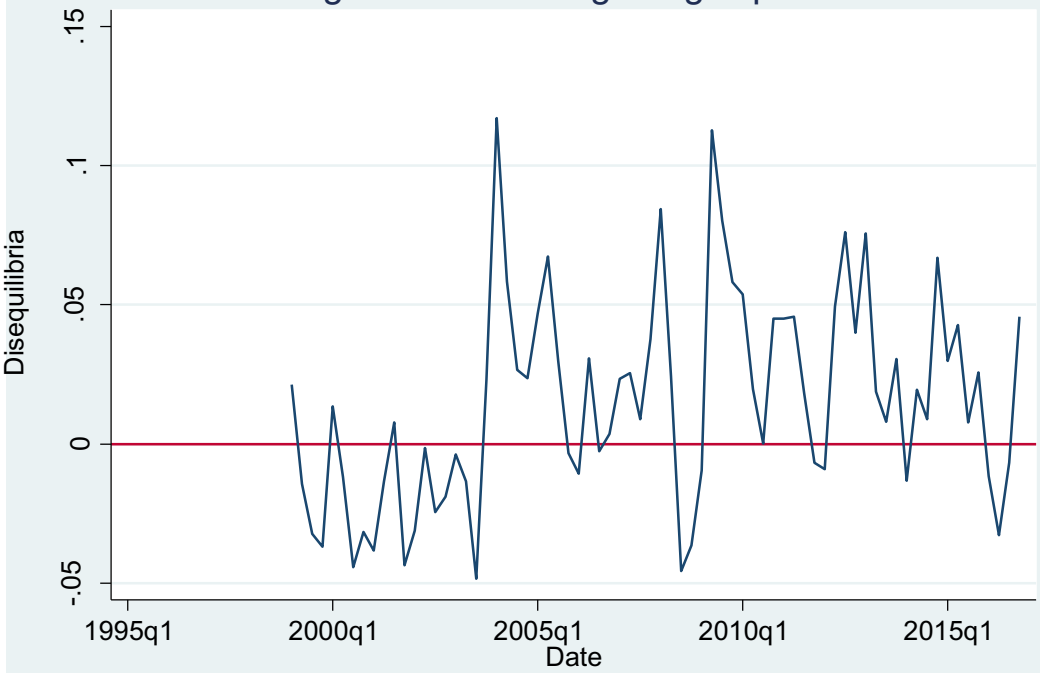


Table. 5

Estimation of Vector Error Correction Model for Housing Prices

Cointegrating Equation Log(House Price Index)	**Beta** (std.error)
Constant	-9.413681 (.)
Log(Real Per Capita GDP), y_t	.2996604 (.7318847)
Log(Land Supply with 5 lags), h_{t-5}	-.943447 *** (.1849248)
Log(Real Construction Cost), c_t	4.289873*** (1.057248)
Real Interest Rate, r_t	-.0943063*** (.0191209)
Log(Real Doemstic Credit), dcr_t	.0435953 (.7376042)
Chi-square	439.7697 ***
AIC	-17.45356
Number of Observations	71(1999Q1-2016Q3)

(1) *** 1% significance, ** 5% significance and *10% significance

Real per capita income (y) has a positive long-run effect on house price index. A one per cent increase in real per capita income will lead to a 0.3 per cent increase in house price index: if real per capita increases by HK$10000, the house price index will increase by 3 units. As income per capita increases, people have a higher level of disposable income, which can be

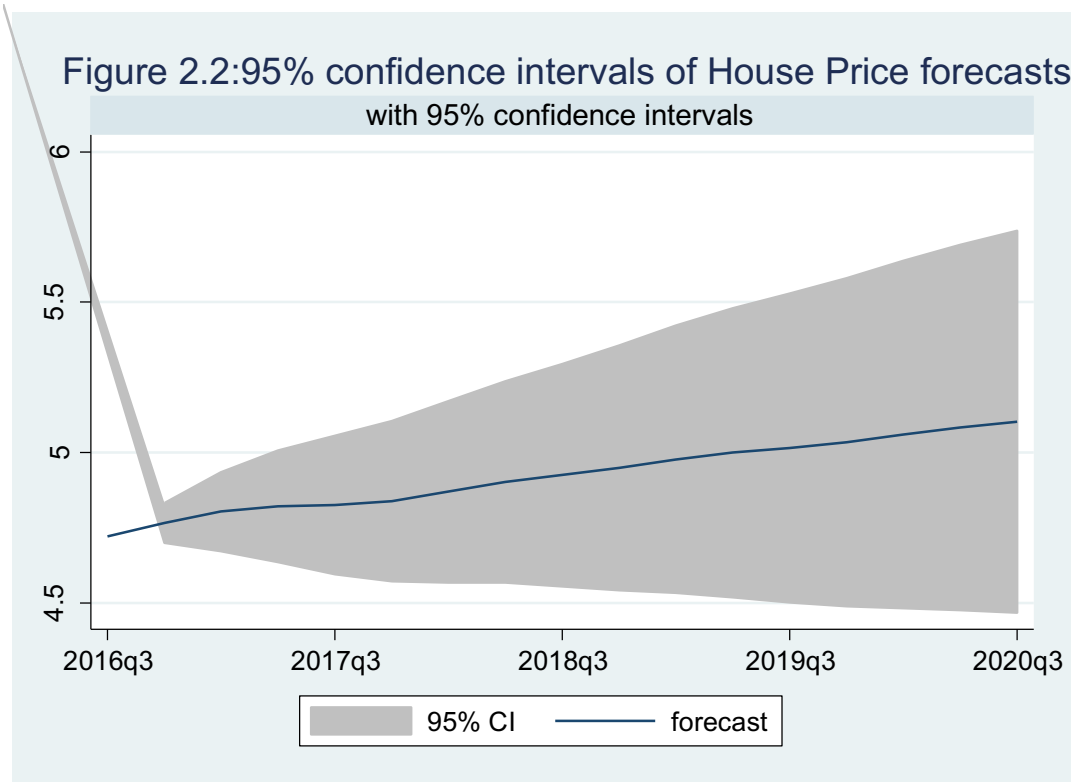
spent for consumption and saving. People may choose to acquire properties for own use or investment, which increases the demand for property, therefore raising the house prices. The sign of this coefficient is line with Leung, Chow and Han (2008) and Craig and Hua (2011), however, the coefficient is not statistically significant at 10% of level of significance, as the p-value suggests that the null hypothesis that the variable is insignificant cannot be rejected at 10% of level of significance. This suggests that the rising trend of the prices is not significantly caused by the improved income.

Land supply with 5 lags has a negative long-run effect on house price index. A one per cent increase in land supply will lead to 0.943 per cent decrease in house price index after five quarters: if land supply increases by 10000 square metres, the house price index decreases by 9.43 units after five quarters. As land supply increases, more housing units are available for purchase after the completion. Assuming demand for housing in unchanged, housing prices will decrease as more housing units are available in the market. The coefficient is statistically significant at 1% level of significance and the sign of it is in line with the literature.

Construction cost index has a positive long-run effect on house price index. A one per cent increase in real construction cost will lead to a 4.29 per cent increase in house price index: if the construction cost index increases by 0.01 units, the house price index will increase by 0.043 units. As construction cost increases, construction companies demand higher fees from real estate developers, who in turn transfer the increase in costs to the house buyers by raising the prices of newly built housing units. The coefficient is statistically significant at 1% level of significance and the sign of it is in line with the literature.

Real interest rate has a negative and the strongest long run effect on house price index. A one unit increase in real interest rate will lead to a 9.43 per cent decrease in house price index: if real interest rate increases by 1% per annum, house price index will increase by 0.0943 units. As real interest rate increases, cost of borrowing from banks increases. An increase in cost of borrowing deters house buyers who require mortgages from buying housing units, because the total cost of house purchase increases. The coefficient is statistically significant at 1% level of significance and the sign of it is in line with the literature.

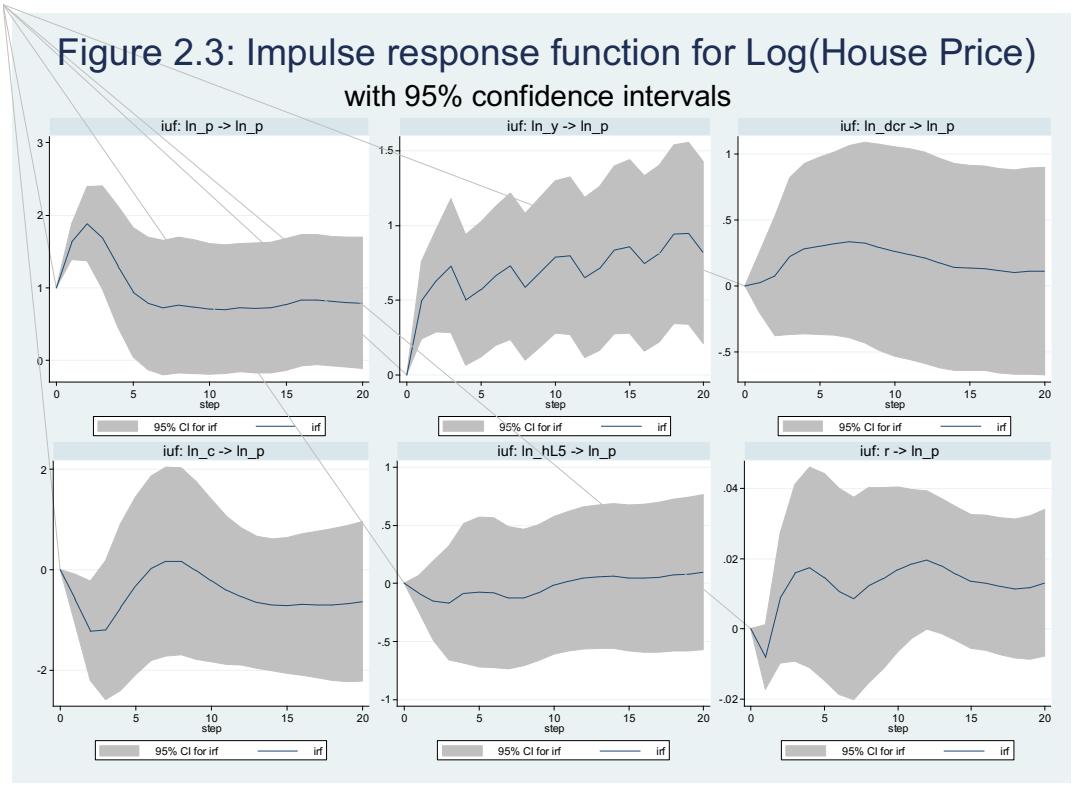
Real domestic credit has a positive long-run effect on house price index. A one per cent increase in real domestic credit will lead to a 0.043 per cent increase in house price index: if real domestic credit increases by HK$10 million, house price index will increase by 0.0004 units. Domestic credit reflects the liquidity conditions in the financial sector of Hong Kong, so a higher value of domestic credit implies higher liquidity in the financial system, therefore consumers have access to larger supply of credit for housing mortgages. Although the sign of the coefficient is in line with the literature, it is statistically insignificant at 10% level of significance. This may imply that house purchases in Hong Kong, despite a rising trend of the prices, have a large cash component.



Taking all the long-run determinants in the VECM into account, the housing prices can be forecasted using STATA. In figure 2.2, starting from 2016Q3, the log of house price index is expected to increase from 4.7 to around 5.1 in 2020Q3. Based on the VECM established, one can expect that the Hong Kong housing prices tend to increase in the future. The increasing trend of housing prices can affect the economic fundamentals of Hong Kong: the middle and lower classes have to save a large proportion of their incomes for down payments, and therefore have a smaller proportion of income for consumption and investment, which will lead to a decline in the domestic economy. Moreover, the VECM has predicted that the income effect on the housing prices is insignificant, it is reasonable to associate the persistently rising housing prices with housing speculation, although this not definitive. In face of the gradual rate hikes by the Federal Reserve, interest rates in Hong Kong are going to follow the same path. Hypothetically, if housing bubble does exist in the housing market of Hong Kong, increases in interest rates will lead to a collapse of the bubble. The government

of Hong Kong should act proactively to introduce monetary, fiscal and housing policies that can alleviate the consequences of a possible bubble collapse.

Impulse Response Functions



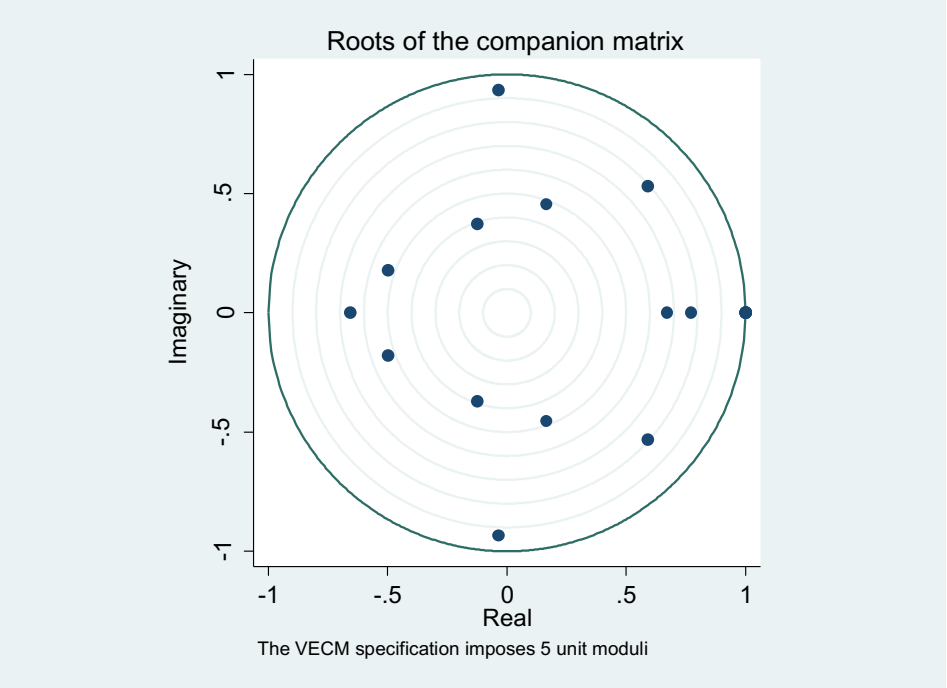
The VECM also has an error correction component which estimates the speed at which a variable, the house price index in this case, adjusts back to the long-run equilibrium after a shock to the other variables. The dynamics are illustrated by a set of impulse response functions in figure 3.3, which is a widely used tool to depict how an economic system responds over time to shocks. The response of house prices to a unit shock of per capita income is positive, and is significant in the first 3 periods. The adjustment of house price index to the equilibrium is slow, as it fluctuates around an increasing trend after the shock. The response to a unit shock of domestic credit is positive and returns to an equilibrium level 19 quarters after the shock. The initial response to a unit shock of construction cost is

negative, and the adjustment to the equilibrium appears 15 quarters after the shock. The response to land supply is insignificant and it adjusts to the initial level 15 quarters after the shock. The response to real interest rate is negative in the first period, but becomes positive afterwards. The adjustment to equilibrium is slow as the response does not die out within 20 quarters after the shock.

Diagnostics tests

The last step of the model estimation is to verify the reliability of the model. Tests for stability, normality and autocorrelation are performed. Figure 2.4 shows a graphical representation of the stability test which checks the stability condition of the VECM. In practice, in a VECM with k variables and r co-integrating ranks, there should be $k - r$ unit moduli in the companion matrix in order for the VECM to be stable. In the VECM, there are 6 variables, and 1 co-integrating vector has been identified. From figure 2.4, one can conclude that the VECM is stable because 5 unit moduli are identified, satisfying the stability condition. The stability condition is a necessary condition to compute the impulse response functions, so the validity of the results is confirmed.

Figure 2.4



Autocorrelation and normality are always the main concerns of econometricians. One of the key assumptions on residuals is that they are independently distributed: there is no correlation between residuals in different time periods. Autocorrelation of residuals, which implies that there is correlation between residuals in different time periods, violates this key assumption. The estimators will still be unbiased and consistent, even if the model suffers from autocorrelation. However, the estimated variances will be biased and inconsistent, affecting the validity of hypothesis tests. The LM test for serial correlation is performed to check whether there exists autocorrelation in the residuals in the VECM, and the result is shown in table 6. The null hypothesis of the test is that there is no autocorrelation at order p, whereas the alternative hypothesis is that there is autocorrelation at order p. The null hypothesis can be rejected at 1% and 5% significance level, but cannot be rejected at 10% significance level. One can conclude that there is evidence for autocorrelation, and that it is not significant at 10% level. Normality of residuals in a model, which implies that the residuals follow a normal

distribution, is another important assumptions of OLS. However, this assumption is rather ideal as one can hardly find series that can generate normal residuals. Failure to satisfy the normality condition is common in applied econometrics. The Jarque- Beta test is performed to check for normality of residuals, and the test result for the overall model is presented in table 6. The null hypothesis of the test is that there is evidence of normality of residuals, whereas the alternative hypothesis is that there is no evidence of normality of residuals. The null hypothesis is rejected at 1%, 5% and 10% significance levels, suggesting that there is no evidence of normality of residuals.

Table. 6

TESTS	VALUES
(1) Lagrange-Multiplier test(3 lags)	63.9662***
(2) Jarque-Bera test	168.239***

(1) Null hypothesis: No autocorrelation at lag order 3
(2) Null hypothesis: Evidence of normality
(3)***1%significance, **5%significance and *10% significance

Reflection

Although some significant results have been produced using the VECM, some issues that can affect the reliability of the results are identified. It is believed that the issues to be discussed below can be used as a starting point for further research in the future.

Proxy For Land Supply

Land supply is an essential component of the VECM because it is a supply factor in the reduced form model of housing prices, which underpins the VECM. There are different ways to measure land supply. One may use land sold for residential purpose, which was employed

in the VECM, or completion of units as a proxy for land supply. The former was chosen over the latter because of data availability. However, completion of units is considered a better proxy. It reflects the actual housing units to be sold and bought in the housing market, and the lagging effect is believed to be less significant than using the other proxy. If one is interested in investigating this topic, choosing completion of units as a proxy of land supply will be worth considering.

Granger Causality Test

The VECM was employed to study the determinants of housing prices in Hong Kong. A VECM is fundamentally a VAR model and treats all variables in the system as endogenous variables, meaning that they interact with each other. In order to justify the effects of the demand and supply variables on the housing prices, Granger Causality tests should have been performed to study the direction of causality. However, STATA's built in command for Granger Causality test was designed to run after estimating a VAR. After estimating the VECM of Hong Kong housing prices, STATA could not perform the Granger Causality test, therefore this paper did not include the discussion of it. If one is interested in investigating this topic, performing Granger Causality tests after estimating a VECM should be considered because it can enhance the reliability and interpretability of the VECM estimation results.

Heteroskedasticity

Heteroskedasticity is one of the concerns of econometricians. When using OLS, homoscedasticity is one of the typical assumptions made: the error term has a constant variance. Heteroskedasticity implies the violation of this assumption, causing biased standard errors and therefore biased inferences and invalid test results. One may notice that test for

heteroskedasticity is missing from this paper. This is because there were no applicable STATA built-in commands to test for heteroskedasticity after estimating the VECM. If heteroskedasticity was confirmed, the Feasible GLS estimator could be used alleviate the problems of biasness. Readers who have an interest in furthering this study can perform tests for heteroskedasticity, such as the Breusch-Pagan test and White's test.

Autocorrelation

Autocorrelation is also a main concern of econometricians. One of the key assumptions on residuals is that they are independently distributed across periods. Autocorrelation of residuals implies that there is correlation between residuals in different time periods. The estimated variances will be biased and inconsistent, affecting the validity of hypothesis tests. The test result confirmed autocorrelation at 1% and 5% confidence level. It is believed that the lagging effect of the proxy for land supply was one of the key factors of autocorrelation. Land sold for residential development was used as a proxy of land supply, but its lagging effect is expected to be significant: the time gap between bidding the land and completing the residential units for sale is large. Choosing a better proxy, as suggested previously, can be an improvement in the VECM. If data availability is a constraint to this improvement, using heteroskedasticity and autocorrelation consistent standard errors can be a valid approach.

Conclusion

Using the VECM, the long run relationship among and short run dynamics of the variables have been identified. The single co-integrating equation, implying a single co-integrating vector, depicts how the macroeconomic variables influence the housing prices over the two decades. The real interest rate has the strongest long run effect on the housing prices followed

by construction cost, and land supply with a 5-quarter lag has the weakest long-run effect. The effects of real per capita GDP and real domestic credit were found statistically insignificant. The forecast shows that the house price index will continue to rise from 2016Q3 to 2020Q3. The impulse response functions capture the short run dynamics of the system. The responses of house prices to a unit shock of per capita income and domestic credit are positive; the responses to a unit shock of construction cost and real interest rate are negative. The response to a unit shock of land supply is insignificant. The adjustments of house prices to the equilibrium after those shocks are all slow. The VECM satisfies the stability condition stable as 5 unit moduli were identified, so the results of the impulse response functions are valid. The VECM has been identified to suffer from autocorrelation, resulting in biased and inconsistent estimated variances, which may lead to invalid hypothesis tests. Some model issues and their possible solutions were discussed in the hope of enhancing future research on this topic. All in all, the recent rising trend of housing prices in Hong Kong is partly explained by improved macroeconomic conditions, so it is reasonable to think that housing market speculation plays a role in the rising trend. Including this component in the analysis can be a starting point for further research on this topic.

Reference

Abraham, J. M., & Hendershott, P. H. (1996). Bubbles in metropolitan housing markets. *Journal of Housing Research,* 7(2), 191-207.

Ahuja, A., & Porter, N. (2010). Are House Prices Rising Too Fast In Hong Kong SAR?. *IMF Working Paper No. WP/10/273.*

Capozza, D. R., Hendershott, P. H., Mack, C., & Mayer. C. J. (2002). Determinants of Real House Price Dynamics. *NBRE Working Paper No. W9262*.

Craig. R. S., & Hua. C. (2011). Determinants of Property Prices in Hong Kong SAR: Implications for Policy. *IMF Working Paper No. WP/11/277.*

Demographia. (2017). 13th Annual Demographia International Housing Affordability Survey: 2017[Online] at http://www.demographia.com/dhi.pdf (Accessed on 10.04.17)

Dickey, D., & Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econmetrica,* 49(4), 1057-72.

Engle, R. F., & Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica,* 55(2), 251-276.

Gerlach, S., & Peng, W. (2005). Bank Lending and Property Prices in Hong Kong. *Journal of Banking and Finance,* 29(2), 461-481.

Granger, C. W. J., & Newbold, P. (1974). Spurious Regressions in Econometrics. *Journal of Econometrics,* 2(2), 111-120.

Granger, C. W. J. (1981). Some Properties of Time Series Data and Their Use in Econometric Model Specification. *Journal of Econometrics,* 16(1), 121-130.

Glindro, E. T., Subhanji, T., Szeto, J., & Zhu, H. (2011). Determinants of House Prices in Nine Asia-Pacific Economies. *International Journal of Central Banking,* 7(3), 163-204.

Gonzaol, J., & Lee, T.-J. (1998). Pitfalls in testing for long run relationships. *Journal of Econometrics*, 86, 129-154

Johansen, S. (1988). Statisical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control,* 12(2-3), 231-254.

Leung. F., Chow. K., & Han. G. (2008). Long-term and Short-term Determinants of Property Prices in Hong Kong. *HKMA Working Paper No. 15/2008.*

Panagiotidis, T., & Printzis, P. (2016). On the macroeconomic determinants of the housing market in Greece: a VECM approach. *International Economics and Economic Policy,* 13(3), 387-409.

Peng, W. (2002). What Drives Property Prices in Hong Kong? *HKMA Quarterly Bulletin* (8/2002). Hong Kong: Hong Kong Monetary Authority.