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# ON THE DYNAMIC RELATIONSHIPS BETWEEN THE HOUSING MARKET, STOCK MARKET AND MACROECONOMIC VARIABLES IN HONG KONG

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## ABSTACT

The relationship between the housing market, stock market and macroeconomic variables has long been a topic of concern to both academics and practitioners. This paper examines the short-run dynamics and long-run relationships between the residential property price index and the stock market index and four selected macroeconomic variables in Hong Kong. The Johansen (1991) cointegration approach and the vector error correction model (VECM) approach are used to examine the monthly time series during the sample period from 2004 to 2019. Our results show that there is a cointegration relationship between the residential property price index and the stock market index and selected macroeconomic variables. There is evidence that the Hang Seng Index, money supply (M3), total loans and unemployment rate are significantly associated with the residential property price index, while the consumer price index has no significant impact on the residential property price index in the short-run dynamics. Also, only the Hang Seng Index and two macroeconomic variables have a long-run cointegration relationship with the housing market. This is the first attempt to shed light on both short-run and long-run relationships between two capital markets and macroeconomic variables in the context of Hong Kong. Our findings provide important implications for relevant government departments to stabilise the housing market and help practitioners form effective investment strategies.

**Keywords:** Housing market; Stock market; Macroeconomic variables; Vector error correction model (VECM); Cointegration test

## 1 INTRODUCTION

Empirical research on the relationship between stock and housing markets has always been the focus of academic circles (e.g., Case et al., 2005; Ding et al., 2014; Gokmenoglu & Hesami, 2019; Li et al., 2015). For most countries, stock

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and housing markets are pivotal capital markets and are important for investors. The excessive volatility of asset prices in these two markets has brought huge shocks to many economies in the past. In the 1990s, Japan fell into economic recession due to the bursting of its real estate bubble. At the end of the 20th century, many countries suffered the collapse of capital markets due to the Southeast Asian financial crisis. In 2008, the United States (US) subprime mortgage crisis triggered a global financial crisis – and so on. Therefore, the violent volatility of the stock market and housing market can trigger massive turbulence in the economic and financial environment.

Previous studies have shown that among the many influencing factors, macroeconomic factors play a vital intermediary role in asset prices in the stock and housing markets and have also become the theoretical basis for macroeconomic policy formulation (Andrew & Meen, 2003; Grum & Govekar, 2016). In addition, some researchers have studied the relationship between house prices, stock markets and macroeconomic variables (Antonakakis & Floros, 2016; Antonakakis et al., 2016; Beltratti & Morana, 2010; Damianov & Elsayed, 2018). On the other hand, the importance of economic fundamentals to stock market returns has been recognised. There is ample evidence that the expected fluctuations in stock returns are related to economic conditions expressed by key macroeconomic variables. Specifically, the house prices of a city or country can reflect the consumption level and economic strength of the city or country. Generally speaking, house prices are affected by supply and demand and monetary policy (Stroebel & Vavra, 2019). Although previous studies have analysed the relationship between stock and housing markets in countries such as the US, United Kingdom (UK) and Australia (Apergis & Lambrinidis, 2011; Lee et al., 2017; Okunev et al., 2000), these studies rarely mention the role of macroeconomic factors. In addition, few studies have dealt with this intricate relationship in the context of Hong Kong. This paper is rooted in Hong Kong's special institutional environment, and aims to comprehensively analyse the effects of stock market fluctuations and changes in macroeconomic factors on the housing market.

This paper uses the Johansen cointegration test to estimate the integration between the housing market, stock market and macroeconomic variables in Hong Kong from January 2004 to December 2019. In addition, this paper estimates the short-run and long-run relationships between the residential property price index and the stock market index and four selected macroeconomic variables through VECM. As far as this paper is concerned, this is the first attempt to reveal the short-run dynamics and long-run relationship between the two capital markets and macroeconomic variables in the context of Hong Kong. Our findings help economic practitioners and relevant government departments to better understand how the stock market and macroeconomic factors drive the residential housing market in Hong Kong. The results also contribute to the literature on the Hong Kong housing market.

The remainder of this paper is as follows: Section 2 provides the literature review on the relationship between house prices, stock price movements and the macroeconomic environment. Section 3 presents the sample data and methodology used in the study. The empirical results and findings are reported in Section 4. The last section concludes the paper and outlines the practical implications.

## 2 LITERATURE REVIEW

### *2.1 THE LINKAGE BETWEEN THE STOCK MARKET AND THE HOUSING MARKET*

The stock market and housing market are two important capital markets for investors. The relationship between these two markets attracts much attention from both investors and academics and helps to provide important insight into portfolio optimisations as well as into regional economic structure (Lin & Lin, 2011). On the one hand, stock is one of the most convenient options for investment, with high information transparency and liquidity. On the other hand, residential real estate is a less liquid investment option with a high cash value, especially in Asian regions. Prior literature indicates that the housing market may react independently towards the stock market because of various government interventions and market conditions. Specifically, prior studies have demonstrated the impact of the stock market on the housing market in developed economies with inconsistent results due to different sampling and research methodology (Lin & Lin, 2011; Ling & Naranjo, 1999; Liow & Yang, 2005; Nguyen & Bui, 2019).

In one of the first studies, Liu et al. (1990) find that the securitised real estate market in the US is linked to the stock market, while the commercial real estate market is segmented from stock market. Lizieri and Satchell (1997) demonstrate a significant contemporaneous link between UK property stock returns and equity market returns. Other researchers use a variation of the linear cointegration technique and an error correction mechanism to capture both the short-run and long-run relationships between the real estate and stock markets. Tuluca et al. (2000) discover that capital and real estate market price indices (T-bills, shares, securities, securitised real estate and direct real estate) are cointegrated. Furthermore, since two cointegrating vectors are present, their scheme of five asset indices is controlled by three common (nonstationary) factors.

Liow (2000) evaluates the cointegration characteristics of commercial real estate prices, property stock prices and three macroeconomic variables in the Singapore economy from 1980 to 1997. Using the Johenson cointegration technique and VECM, the results show that the commercial real estate market is cointegrated with the property stock market and macroeconomic conditions in the long run, and about 10% of the deviation between the actual and equilibrium value of commercial real estate price is corrected in each quarter. Using monthly data in Chinese stock and property markets from 1999 to 2010, Adcock et al. (2016) find that property and stock markets are integrated at the national level. They further find a negative correlation between the B-share prices and property prices.

Using 14 years' data from 17 countries, Quan and Titman (1999) find a strong positive relationship between stock returns and changes in office real estate prices. They state that changes in perceptions of future economic development that are independent of current fundamentals will drive real estate and stock prices up and down. However, their study does not distinguish the effect of expected and unforeseen changes in real estate prices on stock prices. In the study of Liow et al. (2015), it is found that real estate securities and stock markets have reasonable degree of correlation dependences by using the data in eight markets from 1995 to 2002.

In the previous literature, there are two well-known mechanisms that can help explain the relationship between house prices and stock prices. The first mechanism is the wealth effect, which states that if stock prices rise, then the wealth of investors will increase (Case et al., 2013). Under this mechanism, investors will sell stocks and invest in the real estate market to diversify their investment portfolio, thereby increasing the demand for home purchases. The wealth effect indicates the causal effect of exogenous changes in people's wealth on consumer behaviour. As investors feel the increase in wealth, a simultaneous increase in investment in various assets will appear (Quan & Titman, 1999). Therefore, as a result of the wealth effect mechanism, the stock market will lead the real estate market. Based on this effect, researchers demonstrate that the synchronous relationship between stock market performance and real estate prices will strengthen if expectations for future rents and profits change simultaneously.

The second mechanism is the credit price effect, which proposes that real estate provides investors with good loan collateral. Based on the credit price effect, there is a causal relationship between stock prices and house prices. Rising house prices can be used as collateral to promote consumption and investment by enterprises, thereby driving stock prices to rise. Thus, rising housing prices can increase investors' borrowing capacity, allow investors to borrow more money at a lower cost and encourage investors to buy more stocks. In this case, the real estate market will lead the stock market (Kapopoulos & Siokis, 2005).

## *2.2 THE LINKAGE BETWEEN MACROECONOMIC FACTORS AND THE HOUSING MARKET*

The housing market value is inseparable from the general economic cycle (Quigley, 1999; Wang, 2003). When the economic environment is good, people will be more willing to buy residential real estate, thereby increasing the demand for housing. As the trading volume increases, units with lower prices will be traded first. In addition, after units with lower prices are traded, buyers can only choose units with higher prices, and the transaction price will increase accordingly. On the other hand, when the economic environment deteriorates, people's willingness to buy residential real estate is likely to decline, and housing demand will also decline. Due to the limited transaction volume, if the owner wants to sell his house, he must offer a lower price to attract buyers, and the transaction price will decrease accordingly (Jalil et al., 2018).

There is a vast literature on the impact of macroeconomic factors on real estate prices. The previous literature used various models to analyse the relationship between macroeconomic variables and real estate price movements. For example, previous literature shows that real estate prices move in the direction of currency shocks (Lastrapes, 2002), and around 40% of real estate price movement in G7 countries is related to global macroeconomic shocks (Beltratti & Morana, 2006). In addition, Adams and Füss (2010) clarified the relationship between the unemployment rate and money supply on real estate demand and housing prices.

According to Bardhan et al. (2008), GDP is one of the most important factors affecting real estate demand. Kepili and Masron (2011) looked into the relationship between real estate prices and GDP. In their study, they compared the relationship between real estate prices, foreign investment growth and GDP in Malaysia and South Korea. They found that due to the simultaneous increase in foreign investment, South Korea's GDP and real estate prices grew even higher. Chin (2003) investigated the impact of macroeconomic factors on commercial real estate rental prices in five Southeast Asian cities from 1988 to 2001: Singapore, Hong Kong, Taipei, Kuala Lumpur and Bangkok. GDP, credit interest rate, consumer price index, development scope, unemployment rate and the surface of market concepts were all considered in his study. He found that the surface of the business premise and the credit interest rate were the two most important factors determining real estate rental prices.

However, recently there has been a limited but increasing research initiative aimed at bridging the gap between the two literatures and clarifying issues that are important to both macroeconomics and housing economists.

## *2.3 HONG KONG'S TWO CAPITAL MARKETS AND MACROECONOMY*

The housing market and the stock market are two well-known markets in Hong Kong. One of several new innovations after Hong Kong returned to China in 1997 was the creation of a real estate investment trust (REIT). Due to its high degree of transparency and external attention, the Hong Kong market has been rated as the freest economy in the world by the Heritage Foundation in Washington, D.C. for many years (Yiu et al., 2013). Real estate-related stocks account for a large portion of the Hong Kong stock market. Real estate or real estate-related businesses account for 10 of the top 20 companies on the list. The six major real estate developers own approximately 40% to 50% of new residential and commercial properties on the market.

Hong Kong is recognised as one of the freest economies in the world. For nearly a century, the Hong Kong government has promoted a capitalist economy (Li, 2014). However, the political situation in the region, especially the relationship between mainland China and the US and the relationship between mainland China and other regions, has had a significant impact on its economy. Before 1997, due to the impact of the Asian financial crisis, Hong Kong capital continually left the stock exchange, and the Hang Seng Stock Index hit a record low. After China promised free economic growth, Hong Kong regained its commercial appeal. In addition, Hong Kong's financial market was paralysed by the SARS (severe acute respiratory syndrome) outbreak in 2003. The Hong Kong stock market did not pick up until signing the Closer Economic Partnership Arrangement (CEPA) and allowing mainland Chinese visitors to enter (Miyakoshi et al., 2020).

Given that Hong Kong is an international financial centre in Asia and its stock market value ranks among the top 10 in the world, it is important to investigate the determinants of the Hong Kong housing market. In addition, Hong Kong's unique economic environment has caused uncertainty in the relationship between house prices and stock market performance. Specifically, the Asian financial crisis occurred after Hong Kong returned to mainland China in 1997, and the average real estate market price dropped by about 50%. Later, the outbreak of SARS stagnated Hong Kong's economic growth, with Hong Kong's real estate and stock markets gradually recovering. At the same time, Hong Kong's capital market has been strongly affected by external macroeconomics, especially after 1997. On the other hand, it is well known that the Hong Kong stock market is one of the most volatile markets in the world, mainly dominated by small and medium-sized firms (Lam & Tam, 2011).

Economic factors (e.g., economic growth, inflation, interest rates, employment rate, financial crisis, etc.) have a significant impact on stock and real estate prices. For example, the subprime mortgage crisis that occurred in the US in 2008 had a huge negative impact on the stock and real estate markets (Haila, 2000). In fact, the disparate effects of these factors on the two markets have repeatedly attracted the attention of taxpayers, families and academics. On the one hand, there is an intertwined partnership in the markets of these two commodities, which means that they are compatible or replaceable. Investors can predict the success of one business by looking at the performance of another business. On the other hand, due to different market factors or government intervention, such as supply and demand distortions, taxation, supply or price regulation, data quality, or other transaction costs, the stock market can react independently of the real estate market. If these two markets are segmented, investors will diversify their investments by buying various securities at the same time. Chiang and Ganesan (1996) show that direct real estate investment in Hong Kong outperforms real estate stocks in terms of risk and return. According to Liang and Webb (1996), investors can invest in commercial real estate and foreign equity. On the other hand, the application of investment appraisal methods requires an understanding of how various investment tools interact. However, there are few recent studies on the relationship between stock prices, house prices and macroeconomic factors. Thus, it is of great significance to analyse the impact of macroeconomic factors and stock price fluctuations on the Hong Kong housing market.

### *2.4 RESEARCH GAP*

Most studies have found that real estate market is independently affected by stock market movements and macroeconomic factors (Alshogeathri, 2011; Ibrahim, 2010; Singh et al., 2011). However, the question of how the performance of the stock market and macroeconomic factors together affect the housing market must be answered. Given that the emerging Asian real estate market has attracted global attention, this paper uses different econometric techniques to study the joint impacts of selected macroeconomic variables and stock market movements on Hong Kong house prices, and explores the possible existence of wealth effect or credit price effect.

## 3 DATA AND METHODLOGY

### *3.1 DATA*

This paper uses monthly time series to explore the short-run dynamics and long-run relationships between the housing market, stock market and macroeconomic variables in Hong Kong. The sample period covers 16 years from January 2004 to December 2019. All the monthly time series are downloaded from the database of the Census and Economic Information Centre (CEIC) and the official website of the Hong Kong Census and Statistics Department.

The Residential Property Price Index (RPPI) published by the Hong Kong Rating and Valuation Department is used as a proxy for fluctuations in house prices. The index measures the average price volatility of residential houses of roughly the same properties. It is a timely, accurate and comparable indicator that reflects the residential price trends in different districts. Due to the breadth of the sample, this paper aims to provide useful information for the general public and even for economists. The base period of RPPI is 1999.[1] RPPI shows

[1] The RPPI consists of five house classes which are classified by reference to floor area as follows: Class A (saleable area < 40 $m^2$); Class B (saleable area of 40 $m^2$ to 69.9 $m^2$); Class C (saleable area of 70 $m^2$ to 99.9 $m^2$); Class D (saleable area of 100 $m^2$ to 159.9 $m^2$) and Class E (saleable area of ≥ 160 $m^2$).

**Table 1. Description of Variables**

| Variables | Proxies | Unit | Abbreviations |
|---|---|---|---|
| Housing Market | Residential Property Price Index | 1999 = 100 | RPPI |
| Stock Market | Hang Seng Index (Month End) | 31 Jul 1964 =100 | HSI |
| Macroeconomic Factors | Money Supply (M3) | HKD Billion | M3 |
| | Consumer Price Index | Oct 2014 to Sept 2015 = 100 | CPI |
| | Total Loans | HKD Billion | TL |
| | Unemployment Rate | % | UR |

the long-run trend of housing prices in Hong Kong, and the weight of the price index is calculated based on the number of transactions in the current month and the previous 11 months for residential buildings.

The Hang Seng Index (HSI) is used as the indicator for the performance of the Hong Kong stock market. The money supply (M3), consumer price index (CPI), total loans (TL) and unemployment rate (UR) are used as the indicators of the macroeconomic environment based on previous literature (Chappell & Keech, 1986; Chen et al., 2005; Hussin et al., 2012; Tanasković & Jandrić, 2015; Tursoy et al., 2008). Table 1 presents a summary of the selected variables and proxies with their abbreviations.

## *3.2 METHODOLOGY*

This paper uses Johansen's (1991) VECM to explore the dynamic relationships between house prices, the stock market and macroeconomic factors. The specification of the characteristics of the time series variables in the model, such as whether they are stationary or nonstationary, is a prerequisite for VECM estimation. VECM is a restricted vector autoregression (VAR) optimised for cointegrating nonstationary variables (Obayelu & Salau, 2010). The VECM definition limits the long-run behaviour of endogenous variables to cointegration relationships, thereby allowing short-run dynamics. VECM is commonly used to model nonstationary economic variables that are interconnected through long-run relationships (Bekhet & Yusop, 2009). A 'standard' VECM means that the variable changes in a linear manner to achieve its long-run equilibrium.

According to previous literature, VECM can estimate the cointegrating vector more efficiently than Engle and Granger's (1987) two-step error correction model (Maysami & Koh, 2000). One of the main advantages of cointegration analysis is that by establishing an error correction model (ECM), we can examine the dynamic linkage between different variables and the adjustment process to long-run equilibrium (Obayelu & Salau, 2010). Specifically, given that VECM is an information maximum likelihood estimation model, VECM allows for the testing of cointegration in an integrated system of equations in one step and without normalising specific variables.

# 4 EMPIRICAL RESULTS

## *4.1 DESCRIPTIVE STATISTICS*

Table 2 presents the descriptive statistics for the residential property price index, Hang Seng Index and four selected macroeconomic variables in Hong Kong over the period from January 2004 to December 2019 (the number of observations is 192). The skewness statistic measures the extent of the probability distribution having a positive or negative tail concerning its departure from symmetry. The normal curve of the variable is symmetrical when the value of the skewness statistic equals zero. The results show that all variables, except UR, have approximately zero skewness. In any case, the skewness of UR is 1.22, which does not greatly deviate from symmetry. The kurtosis statistic measures the extent of the distribution trend of having a relatively larger proportion of observations around the centre. The normal curve of the variable is mesokurtic when the value of the kurtosis statistic equals 3. Both HSI and UR are fairly close to 3 while RRPI, M3, CPI and TL are slightly below 3. In any case, no large deviation from mesokurtic is found. During the sample period, RRPI ranges from 69.50 to 396.90 and the ratio of high-low is almost 6 times, while HSI ranges from 11942.96 to 32887.27 and the high-low ratio is about 2.7 times only. It indicates that the housing market is more volatile than the stock market in Hong Kong.[2] The high-low ratios of

**Table 2. Summary Statistics of Variables (January 2004 to December 2019)**

| | RRPI | HSI | M3 | CPI | TL | UR |
|---|---|---|---|---|---|---|
| Mean | 207.72 | 21,560.20 | 8,747.28 | 89.40 | 5,441.56 | 3.97 |
| Median | 185.75 | 21,998.49 | 8,148.24 | 88.00 | 5,116.87 | 3.50 |
| Maximum | 396.90 | 32,887.27 | 14,803.92 | 111.40 | 10,376.70 | 7.10 |
| Minimum | 69.50 | 11,942.96 | 3,848.51 | 72.30 | 2,041.37 | 2.60 |
| Standard Deviation | 102.65 | 4,757.77 | 3,492.53 | 12.70 | 2,682.11 | 1.14 |
| Skewness | 0.35 | –0.16 | 0.28 | 0.18 | 0.34 | 1.22 |
| Kurtosis | 1.76 | 2.47 | 1.74 | 1.56 | 1.74 | 3.55 |
| Observations | 192 | 192 | 192 | 192 | 192 | 192 |

[2] The coefficient of variation (CV) of RRPI is 0.494 while the CV of HSI is 0.221. This can further confirm the higher volatility in real estate market than in stock market in Hong Kong.

the macroeconomic variables are 3.8, 1.5, 5.1 and 2.7 times for M3, CPI, TL and UR, respectively. The high ratio of TL may be associated with the high ratio of RRPI. In Hong Kong, it is very common for residents or investors taking mortgage to buy or invest in properties. The close association between the two ratios of TL and RRPI is not unexpected.

## *4.2 UNIT ROOT TEST*

In this paper, we employ Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) approaches to conduct the unit root test at the level and first difference of all the variables. The hypotheses of both unit root tests are as follows:

$H_o$: Variable has a unit root.
$H_a$: Variable does not have a unit root.

Rejection of the null hypothesis indicates that the time series is stationary while non-rejection means that the series is not stationary. Table 3 exhibits the results of the unit root tests.

In the ADF and PP unit root tests, the null hypothesis that the series is nonstationary cannot be rejected for all the variables at all the conventional levels, while the null hypothesis that the first difference is nonstationary is rejected for all the variables at the 5% significance level. The results indicate that the series can be described as integrating in order one, $I(1)$, for all the variables. Hence, the cointegration test can be used to determine the number of cointegration relationships between the six variables.

## *4.3 COINTEGRATION TEST*

First, we develop an unrestricted VAR model (see Appendix) to determine the optimal lag length ($p$), which is selected by five criteria: sequentially modified LR test statistic (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ). It is worth noting that the smaller the value of the criterion, the better the model selected under this selection criterion. Table 4 reports the lag order selection criteria from VAR(1) to VAR(3). The results show that the optimal lag length for the VAR model is 2 (selected by SC and HQ) or 3 (selected by LR, FPE and AIC). Most studies usually choose the optimal lag length based on the criteria of AIC and SC. When AIC and SC select different lag lengths, the LR criteria should be used to select the optimal lag length. Therefore, this paper finally uses the LR criteria to determine the optimal lag length in the VAR model as 3.

Second, the Johansen cointegration test is used to determine the number of cointegration relationships between the variables. The number of cointegrating

**Table 3. ADF and PP Unit Root Tests (January 2004 to December 2019)**

| | Level | | | | First Difference | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | ADF | PP | Trend | Intercept | ADF | | PP | | Trend | Intercept |
| RPPI | –3.4035 (0.0539) | –2.4444 (0.3556) | Yes | Yes | –6.6494 (0.0000) | ** | –5.8428 (0.0000) | ** | No | Yes |
| HSI | –3.0354 (0.1254) | –3.3471 (0.0619) | Yes | Yes | –13.3091 (0.0000) | ** | –13.3091 (0.0000) | ** | No | No |
| M3 | –2.5751 (0.2923) | –2.4839 (0.3358) | Yes | Yes | –12.0438 (0.0000) | ** | –15.5178 (0.0000) | ** | No | Yes |
| CPI | –2.2078 (0.4820) | –3.1692 (0.0938) | Yes | Yes | –3.5249 (0.0084) | ** | –17.562 (0.0000) | ** | No | Yes |
| TL | –2.2361 (0.4664) | –2.3949 (0.3810) | Yes | Yes | –4.9879 (0.0000) | ** | –15.684 (0.0000) | ** | No | Yes |
| UR | –2.6876 (0.0781) | –2.5734 (0.1003) | No | Yes | –3.9627 (0.0001) | ** | –7.4739 (0.0000) | ** | No | No |

Notes: Mackinnon (1996) one-tailed $p$-values are reported in parentheses. * and ** indicate statistical significance at 5% and 1% levels, respectively.



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**Table 4. Selection of Optimal Lag Length in VAR Model (January 2004 to December 2019)**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 1 | –4420.465 | n/a | 1.22e+13 | 47.16 | 47.78 | 47.41 |
| 2 | –4275.233 | 272.022 | 3.84e+12 | 46.00 | 47.24* | 46.50* |
| 3 | –4232.721 | 76.93* | 3.59e+12* | 45.93* | 47.79 | 46.68 |

Note: * indicates the lag order selected by the corresponding criterion.

vectors ($r$) is calculated by two likelihood ratio techniques: trace statistic, $\lambda_{trace}$, and maximum eigenvalue statistic, $\lambda_{max}$:

$$\lambda_{trace} = -T\sum_{i=r+1}^{m}\ln\left(1-\hat{\lambda}_i\right) \quad (1)$$

$$\lambda_{max} = -T\ln(1-\hat{\lambda}_{r+1}) \quad (2)$$

where T is the number of observations, $\hat{\lambda}_i$ denotes the descending ordered eigenvalues $\hat{\lambda}_1 > \cdots \hat{\lambda}_m > 0$, and $r$ is the number of cointegrating vectors. The trace test has the following hypotheses:

$H_o$: The number of cointegration relationships $\leq r$
$H_a$: The number of cointegration relationships $> r$

And the two hypotheses in the maximum eigenvalue test are as follows:

$H_o$: The number of cointegration relationships $= r$
$H_a$: The number of cointegration relationships $= r + 1$

Table 5 shows the results of the trace and maximum eigenvalue statistics of the Johansen cointegration test. Both statistics significantly reject the hypothesis that there is no cointegration relationship at the 1% level and the hypothesis that there is a cointegration relationship at the 5% level. The findings indicate that RPPI is integrated with HSI and all selected macroeconomic variables, and there are two cointegrating equations. Therefore, VECM can be employed for subsequent analysis. Our results are similar to the findings of Pillaiyan (2015) that there are two cointegration equations or vectors between the housing market and macroeconomic variables in Malaysia. Abul (2019) also found that there is more than one cointegration relationship between the stock and house markets in Kuwait. For relevance and simplicity, only the estimate of the house price equation of VECM is reported in this study.

**Table 5. Johansen Cointegration Test (January 2004 to December 2019)**

| Number of Cointegrating Equation(s) | Eigenvalue | Trace | 5% Critical Value | Maximum Eigenvalue | 5% Critical Value |
|---|---|---|---|---|---|
| None | 0.2462 | 135.9159** (0.0000) | 95.7537 | 53.4208** (0.0009) | 40.0776 |
| At most 1 | 0.1820 | 82.4951* (0.0035) | 69.8189 | 37.9771* (0.0153) | 33.8769 |
| At most 2 | 0.1213 | 44.5179 (0.0995) | 47.8561 | 24.4354 (0.1202) | 27.5843 |
| At most 3 | 0.0500 | 20.0825 (0.4173) | 29.7971 | 9.6848 (0.7736) | 21.1316 |
| At most 4 | 0.0450 | 10.3977 (0.2514) | 15.4947 | 8.6940 (0.3125) | 14.2646 |
| At most 5 | 0.0090 | 1.7037 (0.1918) | 3.8415 | 1.7037 (0.1918) | 3.8415 |

Note: * and ** indicate statistical significance at 5% and 1% levels, respectively.

## *4.4 VECTOR ERROR CORRECTION MODEL*

The VECM provides the short-run and long-run causal relationships between RPPI and all the endogenous variables – HSI, M3, CPI, TL and UR. The one-period lagged error correction term $ECT_{t-1}$ in VECM indicates the long-run causal relationship, and the Wald test is used to examine the dynamic relationship in the short run. The VECM equation can be written as follows:

$$\Delta RPPI_t = \sum_{i=1}^{p-1}\alpha_i \Delta RPPI_{t-i} + \sum_{j=1}^{p-1}\beta_j \Delta HSI_{t-j} + \sum_{k=1}^{p-1}\gamma_k \Delta M3_{t-k} + \sum_{m=1}^{p-1}\delta_m \Delta CPI_{t-m} + \sum_{n=1}^{p-1}\omega_n \Delta TL_{t-n} + \sum_{s=1}^{p-1}\lambda_s \Delta UR_{t-s} + \theta ECM_{t-1} + c + u_t \quad (3)$$

where $\alpha_i$, $\beta_j$, $\gamma_k$, $\delta_m$, $\omega_n$ and $\lambda_s$ are the coefficient estimates of short-run dynamics, $\Delta$ denotes the first difference of nonstationary series, $c$ is a constant team and $u_t$ is the stationary disturbance. $ECT_{t-1}$ is defined as a cointegrating equation for the long-run relationship with coefficient of $\theta$.

$$ECT_{t-1} = RPPI_{t-1} + \beta_0 HSI_{t-1} + \gamma_0 M3_{t-1} + \delta_0 CPI_{t-1} + \omega_0 TL_{t-1} + \lambda_0 UR_{t-1} + c_0 \quad (4)$$

where $\beta_0$, $\gamma_0$, $\delta_0$, $\omega_0$ and $\lambda_0$ are the coefficient estimates of the respective variables and $c_0$ is the constant term.

Table 6 presents the results of the estimation of VECM using ΔRPPI as a dependent variable. As the optimal lag length is 3, our VECM contains one-period lagged *ECT*, two-period lagged and one-period lagged terms of dependent and independent variables, and a constant term. The coefficient estimate of $ECT_{t-1}$ represents the speed of adjustment of the model from short-run to long-run equilibrium, and must be significantly negative, indicating that there is a long-run causality. Our VECM equation which describes the short-run and long-run relationships between the residential property price index, stock market index and four selected macroeconomic variables in Hong Kong can be written as follows:

$$\begin{aligned}\Delta RPPI_t = {} & 0.7193\Delta RPPI_{t-1} - 0.0976\Delta RPPI_{t-2} + 0.0011\Delta HSI_{t-1} \\ & + 0.0005\Delta HSI_{t-2} - 0.0054\Delta M3_{t-1} - 0.0052\Delta M3_{t-2} \\ & - 0.4417\Delta CPI_{t-1} - 0.1788\Delta CPI_{t-2} + 0.0065\Delta TL_{t-1} \\ & + 0.0029\Delta TL_{t-2} + 2.1952\Delta UR_{t-1} - 5.3515\Delta UR_{t-2} \\ & - 0.0234ECT_{t-1} + 0.7117 \qquad (5)\end{aligned}$$

**Table 6. Vector Error Correction Model Estimation of House Prices (January 2004 to December 2019)**

| Variable | Coefficient | Standard Error | *t*-statistic | *p*-value |
|---|---|---|---|---|
| $ECT_{t-1}$ | –0.0234 | 0.0068 | –3.4363 | 0.0006** |
| $\Delta RPPI_{t-1}$ | 0.7193 | 0.0733 | 9.8189 | 0.0000** |
| $\Delta RPPI_{t-2}$ | –0.0976 | 0.0738 | –1.3228 | 0.1862 |
| $\Delta HSI_{t-1}$ | 0.0011 | 0.0002 | 6.2644 | 0.0000** |
| $\Delta HSI_{t-2}$ | 0.0005 | 0.0002 | 2.7476 | 0.0061** |
| $\Delta M3_{t-1}$ | –0.0054 | 0.0024 | –2.2778 | 0.0229* |
| $\Delta M3_{t-2}$ | –0.0052 | 0.0025 | –2.1222 | 0.0341* |
| $\Delta CPI_{t-1}$ | –0.4417 | 0.2570 | –1.7186 | 0.0860 |
| $\Delta CPI_{t-2}$ | –0.1788 | 0.2572 | –0.6951 | 0.4871 |
| $\Delta TL_{t-1}$ | 0.0065 | 0.0028 | 2.2927 | 0.0221* |
| $\Delta TL_{t-2}$ | 0.0029 | 0.0028 | 1.0332 | 0.3017 |
| $\Delta UR_{t-1}$ | 2.1952 | 1.4508 | 1.5132 | 0.1305 |
| $\Delta UR_{t-2}$ | –5.3515 | 1.3867 | –3.8592 | 0.0001** |
| Constant | 0.7117 | 0.2563 | 2.7770 | 0.0056** |

Note: * and ** indicate statistical significance at 5% and 1% levels, respectively.

where $ECT_{t-1}$ (which represents long-run model) is given as follows:

$$ECT_{t-1} = RPPI_{t-1} + 0.0101HSI_{t-1} - 0.0254M3_{t-1} + 4.6861CPI_{t-1} - 0.0308TL_{t-1} + 41.6684UR_{t-1} - 619.3350 \quad (6)$$

Indeed, equation (6) is obtained from the following VAR equation by rewriting the terms.

$$\begin{aligned} RPPI_{t-1} = &\underset{(-4.8540)}{-0.0101HSI_{t-1}} + \underset{(1.5978)}{0.0254M3_{t-1}} - \underset{(-1.3905)}{4.6861CPI_{t-1}} \\ &+ \underset{(1.9279)}{0.0308TL_{t-1}} - \underset{(-5.7385)}{41.6684UR_{t-1}} + 619.3350 + ECT_{t-1} \end{aligned} \quad (7)$$

The standard errors are reported in parentheses. Substituting equation (6) into equation (5), we get:

$$\begin{aligned} \Delta RPPI_t = &\ 0.7193\Delta RPPI_{t-1} - 0.0976\Delta RPPI_{t-2} + 0.0011\Delta HSI_{t-1} \\ &+ 0.0005\Delta HSI_{t-2} - 0.0054\Delta M3_{t-1} - 0.0052\Delta M3_{t-2} \\ &- 0.4417\Delta CPI_{t-1} - 0.1788\Delta CPI_{t-2} + 0.0065\Delta TL_{t-1} \\ &+ 0.0029\Delta TL_{t-2} + 2.1952\Delta UR_{t-1} - 5.3515\Delta UR_{t-2} \\ &- 0.0234RPPI_{t-1} - 0.0002HSI_{t-1} + 0.0006M3_{t-1} \\ &- 0.1097CPI_{t-1} + 0.0007TL_{t-1} - 0.9750UR_{t-1} \\ &+ 15.2042 \end{aligned} \quad (8)$$

Finally, our overall ordinary equation of VECM is:

$$\begin{aligned} RPPI_t = &\ 1.6959RPPI_{t-1} - 0.8169RPPI_{t-2} + 0.0976RPPI_{t-3} \\ &+ 0.0009HSI_{t-1} - 0.0006HSI_{t-2} - 0.0005HSI_{t-3} \\ &- 0.0048\Delta M3_{t-1} + 0.0002M3_{t-2} + 0.0052M3_{t-3} \\ &- 0.5514CPI_{t-1} + 0.2629CPI_{t-2} + 0.1788CPI_{t-3} \\ &+ 0.0072TL_{t-1} - 0.0036TL_{t-2} - 0.0029TL_{t-3} \\ &+ 1.2202UR_{t-1} - 7.5467UR_{t-2} + 5.3513UR_{t-3} \\ &+ 15.2042 \end{aligned} \quad (9)$$

where adjusted $R^2$ is 0.6033.

The coefficient of $ECT_{t-1}$ in Table 6 is estimated to be negative and highly significant at the 1% level, indicating strong support for the long-run association. The estimate –0.0234 illustrates that about 2.34% of disequilibrium is corrected within one month. In other words, if the residential property price index (RPPI) rises in one month, the stock market (HSI) and macroeconomic factors (M3, CPI, TL and UR) will be jointly pulled back by 2.34% to achieve the long-run equilibrium. In equations (6) and (7), there is evidence that HSI has a significant effect on the long-run equilibrium. HSI is significantly and negatively associated with RPPI in the long run, a result which is in line with our expectations. If the stock price rises, then people will sell the stock and buy a house, because owning a house is the dream of most people in Hong Kong. In the long run, stock prices will face pressure. Conversely, rising housing prices can encourage people to invest in more stocks, driving stock prices up. In any case, in the long run, housing prices will also face pressure.

Considering macroeconomic variables, M3 ($t$ = 1.5978) and CPI ($t$ = –1.3905) do not have any significant relationship with RPPI in the long run. While TL ($t$ = 1.9279) has a marginally significantly positive effect on the long-run equilibrium, UR ($t$ = –5.7385) has a highly significantly negative effect. These two results are not unexplainable and are similar to the findings of previous studies (Dreger & Zhang, 2013; Goodhart & Hofmann, 2008; Irandoust, 2019; Kannan et al., 2012; Su et al., 2019; Xu & Tang, 2014). On one hand, due to the co-movement between residential property prices and commercial property prices, the rise in house prices is associated with the rise in commercial property prices. High commercial property prices indirectly indicate the prosperity and development of business, which leads to low unemployment. On the other hand, the high unemployment rate implies that the business environment is poor, which depresses the prices of commercial and residential properties. Additionally, the increase in total loans indicates that more people are borrowing money to buy houses. The increase in housing demand pushes up house prices. Conversely, when house prices fall, people can more afford to buy a house and use fewer mortgages.

In Table 6, the coefficient estimates of the lagged terms of $RPPI_t$, $HSI_t$, $M3_t$, $CPI_t$, $TL_t$ and $UR_t$ indicate the short-run dynamics between them and $RPPI_t$. Of the five endogenous variables, only $CPI_t$'s one-period and two-period lagged terms are both not statistically significant, suggesting that the changes of HSI, M3, TL and UR affect RPPI in the short run, while the change of CPI has no short-run relationship with RPPI. The results reveal that HSI is positively associated with RPPI in the short run. The result can be explained by the mechanism of the credit price effect which proposes that rising housing prices can encourage investors to buy more stocks and drive stock prices to rise. On the contrary, investors will sell stocks and invest in the real estate market to diversify their investment portfolio if the stock price rises, which is consistent with the mechanism of the wealth effect (Kyle & Xiong, 2001). As a result, the housing market (RPPI) and the stock market (HSI) will have the same co-movement. Similar to the findings in the long-run equilibrium, TL and UR are still positively and negatively correlated with RPPI respectively in the short run. In contrast with the insignificant effect on the long-run equilibrium, M3 has a significantly negative short-run relationship with RPPI. When the money supply increases, people can borrow money to buy a house at a lower cost. However, the money supply affects both the demand and the supply of housing. At the same time, developers have cheaper loans to purchase land, and the construction costs are also lower. If the positive impact on supply is greater than that on demand, then house prices will fall. Conversely, people are more able to buy a house if house prices fall. The demand for mortgage loans then increases, and the money supply needs to meet the demand. In any case, due to the tight land supply in Hong Kong, this will not work in the long term. Finally, whether it is short-run or long-run, CPI does not seem to be one of the macroeconomic factors that determine the house prices in Hong Kong.

In order to test the robustness of the results on short-run relationships, this paper applies the Wald test to examine whether each endogenous variable has a short-run relationship. If there is a dynamic short-run relationship with RPPI, the null hypothesis should be rejected, indicating that at least one coefficient of the two lagged terms should be significantly different from zero; there is no dynamic short-run relationship if the null hypothesis that the two coefficients of the two lagged terms are not significantly different from zero is not rejected.

Table 7 exhibits the results of the Wald test on the dynamic short-run relationship between the house market, stock market and macroeconomic factors. Similar to the results in Table 6, both *F* and Chi-square statistics show that there is no short-run relationship between CPI and RPPI. This result is similar to the findings of Nneji et al. (2013), revealing that people need more time to absorb the influence of house price changes and adjust inflation to a new level. Thus, CPI is not significant in the short run. In summary, the results in Table 6 and Table 7 suggest that HSI and TL have a significantly positive effect on RPPI in the short run, while M3 and UR have a significantly negative effect on RPPI in the short run. There is no short-term relationship between CPI and RPPI. Lastly, our ordinary equation of VECM, i.e. equation (9), has the explanatory power of 60.33% on house prices, which is fairly sufficient.

**Table 7. Wald Test (January 2004 to December 2019)**

| Variable | Hypothesis | Test Statistic | Test Value | df | p-value |
|---|---|---|---|---|---|
| HSI | $H_0: \beta_1 = \beta_2 = 0$ | *F* | 21.238 | (2, 175) | 0.000** |
| | | Chi-square | 42.476 | 2 | 0.000** |
| M3 | $H_0: \gamma_1 = \gamma_2 = 0$ | *F* | 4.718 | (2, 175) | 0.010** |
| | | Chi-square | 9.436 | 2 | 0.009** |
| CPI | $H_0: \delta_1 = \delta_2 = 0$ | *F* | 1.600 | (2, 175) | 0.205 |
| | | Chi-square | 3.200 | 2 | 0.202 |
| TL | $H_0: \omega_1 = \omega_2 = 0$ | *F* | 3.424 | (2, 175) | 0.035* |
| | | Chi-square | 6.847 | 2 | 0.033* |
| UR | $H_0: \lambda_1 = \lambda_2 = 0$ | *F* | 7.612 | (2, 175) | 0.001** |
| | | Chi-square | 15.223 | 2 | 0.001** |

Note: * and ** indicate statistical significance at 5% and 1% levels, respectively.

### 4.5 SERIAL CORRELATION

This paper next uses the Breusch-Godfrey serial correlation LM test to examine if there is a serial correlation in the model. The hypotheses of the test are as follows:

$H_o$: There is no serial correlation between the variables.
$H_a$: There is a serial correlation between the variables.

**Table 8. Breusch-Godfrey Serial Correlation LM Test (January 2004 to December 2019)**

| Test Statistic | Test Value | df | p-value |
|---|---|---|---|
| F | 0.7572 | (2, 173) | 0.4705 |
| Chi-square | 1.6400 | 2 | 0.4404 |

Note: * and ** indicate statistical significance at 5% and 1% levels, respectively.

The *F* and Chi-square statistics in Table 8 are not significant at the 5% level, indicating that the null hypothesis cannot be rejected and that there is no evidence of a serial correlation in the model.

### 4.6 CUMULATIVE SUM (CUSUM) CHART

Lastly, in order to ensure that our model is dynamically stable, this paper uses CUSUM chart as a diagnostic test for stability. Figure 1 shows that the solid line lies within the two dashed lines, which means that the CUSUM line lies within the boundaries of the 5% significance level. The CUSUM chart provides evidence that the model is dynamically stable in the long-run.

## 5 CONCLUSION AND IMPLICATIONS

This paper empirically examines the cointegration relationships between the housing market and the stock market and macroeconomic factors in Hong Kong for the period from January 2004 to December 2019. We use the residential property price index as the proxy for the Hong Kong housing market and the Hang Seng Index as the indicator of the Hong Kong stock market. The variables of the macroeconomic environment are money supply (M3), consumer price index, total loans and unemployment rate. Using the Johansen cointegration test to estimate the integration between the two index series and the macroeconomic series, we find that there is a cointegration relationship between the series. Our VECM shows that there is a significant short-run and long-run dynamic relationship between the stock and housing markets, which

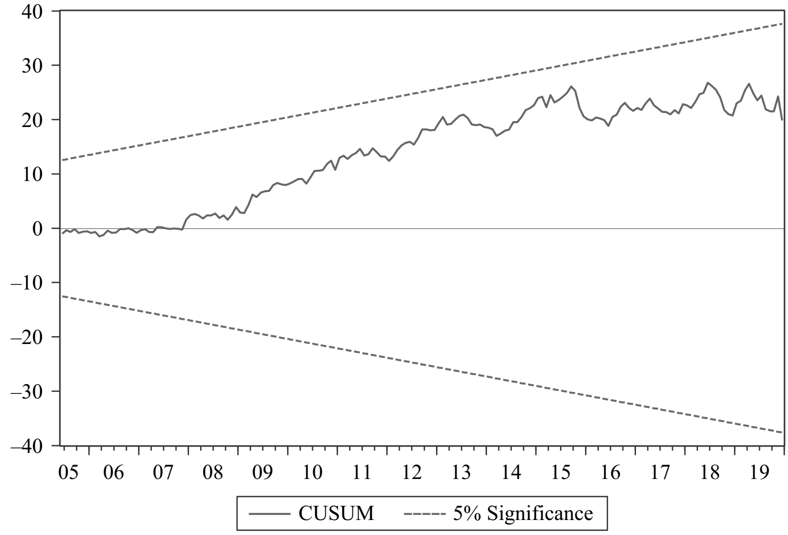


**Figure 1. CUSUM Chart (January 2004 to December 2019)**

can be explained by the wealth effect and credit price effect mechanisms. VECM also gives evidence that total loans and unemployment rate have an influence on the housing market in the short run and long run, while the money supply is correlated with the housing market in the short run only. CPI does not seem to be one of the macroeconomic factors that determine the house prices in Hong Kong regardless of short run or long run. Furthermore, this paper reveals that there is no serial correlation in the VECM by applying the Breusch-Godfrey serial correlation LM test, and uses the CUSUM chart to confirm that our model is dynamically stable in the long run.

The findings of this paper have several practical implications. First, this paper demonstrates that house prices and stock market performance simultaneously influence each other, supported by the wealth effect and the credit price effect. Second, the results indicate that the macroeconomic environment affects house prices in the short and long run. This paper also illustrates the cointegration relationship between house prices, stock market performance and macroeconomic environment. Last but not least, this paper explores whether the government can cool overheated house prices by introducing fiscal policies, which enables policy makers to carefully choose the most appropriate tools to curb demand during the overheated period, thereby stabilising the housing market.

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## APPENDIX VAR MODEL TEST (JANUARY 2004 TO DECEMBER 2019)

$$\begin{bmatrix} RPPI_t \\ HSI_t \\ M3_t \\ CPI_t \\ TL_t \\ UR_t \end{bmatrix}$$

$$= \begin{bmatrix} 1.5921 & 0.0009 & -0.0043 & -0.4556 & 0.0076 & 1.8643 \\ -22.0399 & 1.0285 & -2.4440 & 230.5956 & 4.9060 & -411.2880 \\ -7.6069 & 0.0289 & 0.6434 & -14.5180 & 0.0542 & -169.3257 \\ 0.0135 & -0.0001 & 0.0008 & 0.8308 & 0.0002 & -0.5408 \\ 0.3872 & 0.0218 & -0.3355 & -6.8442 & 0.9612 & -107.1711 \\ 0.0025 & -0.0001 & -0.0003 & -0.0063 & 0.0003 & 1.4703 \end{bmatrix} \begin{bmatrix} RPPI_{t-1} \\ HSI_{t-1} \\ M3_{t-1} \\ CPI_{t-1} \\ TL_{t-1} \\ UR_{t-1} \end{bmatrix}$$

$$+ \begin{bmatrix} -0.7193 & -0.0005 & -0.0005 & 0.3018 & -0.0023 & -7.6160 \\ 23.4475 & 0.0081 & 3.1679 & -355.2089 & -6.7660 & 970.6521 \\ 12.4157 & -0.0156 & 0.1200 & 0.0734 & -0.1147 & 226.8647 \\ -0.0067 & -0.0000 & 0.0020 & 0.0045 & -0.0029 & 0.4878 \\ 2.0758 & -0.0046 & 0.1903 & -6.1627 & -0.0636 & 96.1367 \\ -0.0055 & -0.0000 & 0.0003 & 0.0048 & -0.0002 & -0.6461 \end{bmatrix} \begin{bmatrix} RPPI_{t-2} \\ HSI_{t-2} \\ M3_{t-2} \\ CPI_{t-2} \\ TL_{t-2} \\ UR_{t-2} \end{bmatrix}$$

$$+ \begin{bmatrix} 0.0286 & -0.0004 & 0.0055 & 0.1755 & -0.0025 & 5.4825 \\ -16.3508 & -0.1483 & -0.2534 & 133.0009 & 1.9399 & -491.5532 \\ -6.1185 & -0.0178 & 0.1972 & 20.2944 & 0.1372 & -90.2851 \\ -0.0024 & 0.0001 & -0.0029 & 0.16057 & 0.0026 & 0.0571 \\ -1.7875 & -0.0180 & 0.1436 & 16.16703 & 0.0638 & -16.6533 \\ 0.0022 & -0.0000 & 0.0000 & 0.0097 & -0.0002 & 0.11258 \end{bmatrix} \begin{bmatrix} RPPI_{t-3} \\ HSI_{t-3} \\ M3_{t-3} \\ CPI_{t-3} \\ TL_{t-3} \\ UR_{t-3} \end{bmatrix}$$

$$+ \begin{bmatrix} u_{t\_RPPI} \\ u_{t\_HSI} \\ u_{t\_M3} \\ u_{t\_CPI} \\ u_{t\_TL} \\ u_{t-UR} \end{bmatrix}$$