# What influences real estate volatility in Hong Kong? An ARMA-GARCH approach

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**Abstract**

**Purpose**

This paper aims to examine real estate price volatility in Hong Kong. We analyzed monthly data on housing, offices, retail, and factories in Hong Kong from February 1993 to February 2019 to test whether volatility clusters are present in the real estate market. We also investigate real estate price determinants.

**Design/methodology/approach**

We use the ARCH-LM test to examine the volatility clustering effects in these four kinds of real estate. An ARMA-GARCH model was employed to identify real estate price volatility determinants in Hong Kong.

**Findings**

There was volatility clustering in all four kinds of real estate. Determinants of price volatility vary among different types of real estate. In general, housing volatility in Hong Kong is influenced primarily by the foreign exchange rate (both RMB and USD), while commercial real estate is largely influenced by unemployment. The results of the EGARCH model show that there were no asymmetric effects in the Hong Kong real estate market.

**Research limitations/implications**

This volatility pattern has important implications for investors and policymakers. Residential and commercial real estate have different volatility determinants; investors may benefit from this when building a portfolio. The analysis and results are limited by the lack of data on real estate price determinants.

**Originality/value**

This article is the first study that evaluates volatility in the Hong Kong real estate market using the GARCH class model. To the best of our knowledge, this paper is the first to investigate commercial real estate price determinants.

**Keywords**

Housing Volatility, Commercial Real Estate; Volatility Clustering; GARCH; Asymmetric Effects; Hong Kong

**Paper type**

Research Paper

## Introduction

Real estate is an essential sector in Hong Kong; it contributes approximately 5 percent of GDP from 2014 to 2018 and has a similar share as another key industry, tourism. Apart from its importance to the economy, real estate also plays a vital role in people's lives. In the first quarter of 2020, the proportion of owner-occupiers in the total household number is 51.4 percent. In 1982, the homeownership was 28.7 percent. Given the significance of the real estate market, there has been a great deal of research on this issue. Some of them focus on what is going on in this market, including the real estate cycle (Reed R, Wu H., 2010; Ghent A C, Owyang M T.,2010) and price bubbles (Lai R N, Van Order R.2018; 2017). Others focus on the factors that shape the real estate market, including supply and demand factors (Glaeser E, Huang W, Ma Y., et al, 2017; Hadavandi E, Ghanbari A, Mirjani S M, et al., 2011), the connection between housing prices and market fundamentals (Al-Masum M A, Lee C L., 2019), and the impact of uncertainty shocks (Christou C, Gupta R, Nyakabawo W.,2019).

There has been research on how the return (the first moment) of real estate assets is determined (Campbell S D, Davis M A.,2009). However, the volatility (the second moment) of real estate prices also increases researchers' attention. Volatility clustering is the tendency of massive changes in prices of financial assets to cluster together, which results in the persistence of these magnitudes of price changes. In the 1960s, Benoit Mandelbrot defined volatility as the observation that "large changes tend to be followed by large changes...small changes tend to be followed by small changes" in regard to the stock market. The ARCH model (Robert Engel,1982) and the GARCH(Generalized Auto Regressive Conditional Heteroskedasticity)model (T. Bolerslev, 1986) are proposed to solve time series volatility. Since then, volatility clustering in asset prices has been studied with regard to the stock market (Lamoureux C G, Lastrapes W D., 1990), foreign exchange, other material assets such as gold, and agricultural commodities.

Some recent studies have shown that these price change patterns are also available in the real asset market (Lin Lee C.,2009). These kinds of research on real estate price volatility offer a better understanding of how real estate prices change in a short period. It also enables us to make better policy responses to real estate market changes to stabilize the economic system. There has been a great deal of research on the Hong Kong real estate market: the relationship between housing fundamentals and housing prices (Yiu M S, Yu J, Jin L.,2013), housing returns (Tse R Y C.,1996), the real estate price index (Chau K W, Wong S K, Yiu C Y., 2005), the price discovery process (Chau K W, MacGregor B D, Schwann G M.,2001), and real estate cycles (Wang K, Zhou Y, Chan S H, et al.,2000). The connection between the real estate market and other parts of the economy has also been examined, including the influence of investor sentiment (Lam C H L, Hui E C M., 2018), housing supply (Leung C K Y, Ng J C Y, Tang E C H.,2019), and stock prices (Tse R Y C, 2001). To the best of our knowledge, there has been no research on Hong Kong real estate volatility clusters and their determinants.

This paper aims to determine what factors influence four real estate types (housing, office, retail, and factory real estate) in Hong Kong over the study period from February 1993 to February 2019. First, we use the autoregressive and moving average model (ARMA) to simulate the real estate price change rate. We apply a Lagrange multiplier (LM) test to residuals in this equation to determine if autoregressive conditional heteroscedasticity (ARCH) effects are shown in the real estate market. Then, we use the ARMA-GARCH model to determine how the price volatility of four kinds of real estate is influenced by economic variables such as the interest rate, inflation, and other factors. Then, we will have a deep understanding of how real estate prices shift in a short period and what policy can be used to influence them. This paper is the first study that evaluates volatility in the Hong Kong real estate market using the GARCH class model. It also offers early research investigating commercial real estate price determinants.

The remainder of this paper is organized as follows. Section 2 contains a literature review. In section 3, we introduce the method. We will present how the ARMA-GARCH model is calculated. In section 4, we describe the data and the preliminary test results. In part 5, we show the results of the ARCH test and ARMA-GARCH model estimation and explain our findings, including how they connect with past research. Finally, we offer a brief conclusion to this study, and we provide advice to investors and policymakers.

## Literature Review

There has been a series of studies on real estate volatility in recent years; the ARCH class model is the most widely used model in this literature. There are four main topics related to this issue this issue: (1) identifying volatility clusters in the real estate market, (2) identifying the determinants of housing price volatility, (3) identifying the risk-return relationship in housing, and (4) conducting research on volatility in securitized real estate and land markets. The appendix gives detailed information on the current literature, and then we summarize the main findings within these four topics. It must be noted that an article may involve more than one subject, but we catalog it into one topic according to the main findings.

**(1) Identifying volatility clusters in the real estate market**

Volatility clustering is prevalent in housing markets worldwide. Previous studies have shown a high proportion of volatility in the real estate market. The research on real estate volatility can be traced back to Miller N and Peng L. (2006). They found evidence of time varying housing price volatility in approximately 17 percent of the US's 227 MSAs. Since then, a series of studies have examined the pattern of housing volatility change. Miles W. (2008) found an ARCH effect in more than half of the states in the US. In later research, he also found that more than half of states with significant GARCH effects exhibit the very high persistence found in other assets such as equities (Miles W.,2011).

Volatility clustering effects (ARCH effects) were found in Australia, and six capital cities, asymmetry of the positive and negative shocks, were also documented according to the EGARCH model (Lin Lee C., 2009). In Canada, Lin P, Fuerst F. (2014) conclude that volatility clustering, positive risk-return relationships, and leverage effects are empirically shown to exist in the majority of regional housing markets. In a recent study, Dufitinema J. (2020) found clustering effects in over half of the cities and subareas in all studied types of apartments in 15 regions in Finland. There is also evidence of the asymmetric impact of shocks on housing volatility.

**(2) Identifying the determinants of housing price volatility**

The determinants of housing price volatility have also been widely examined; economic fundamentals, such as GDP, inflation rate and interest rate, are the key variables. In Canada, Hossain B, Latif E. (2009) found that housing price volatility was significantly affected by the gross domestic product (GDP) growth rate, housing price appreciation rate and inflation. In China, Deng Y, Girardin E, Joyeux R. (2018) found that economic fundamentals can indeed account for movements in housing price volatility in Beijing and Shanghai. Reen T A, Razali M N. (2016) found evidence of volatility clustering in more than 50% of Malaysia's housing market, and the significant determinants of housing price volatility in Malaysia were GDP, the housing stock, and the inflation rate.

A recent study on Namibia by Kaulihowa T, Kamati K. (2019) indicated that past period volatility, GDP, and mortgage loans were the critical determinants of housing price volatility. In addition, housing price volatility has been divided into different parts: Lee C L, Reed R. (2013) pointed out that both permanent and transitory volatility components have various determinants. In research on Cyprus by Christos S. Savva and Savva C S, Michail N A. (2017), higher volatility can be associated with higher credit growth during the period.

**(3) Identifying the risk-return relationship in housing**

A positive risk-return relationship has been widely shown in housing. In the UK (Morley B, Thomas D.,2016) and Australia (Lee C L., 2017), housing volatility research shows evidence of a positive risk-return relationship. Begiazi K, Katsiampa P (2018) found that the UK housing market shows evidence of structural breaks that could exaggerate conditional volatility not only at the regional level but also by property type. In a recent study on Finland and its fifteen central regions, Dufitinema J, Pynnönen S. (2020) found that the returns of the studied types of dwellings are long-term dependent; this high level of persistence in the housing price indices differs from that of other assets, such as stocks and commodities.

**(4) Conducting research on volatility in the securitized real estate and land markets.**

Within the research on housing price volatility, recent studies have been conducted on securitized real estate and land price volatility. Liow K H, Ho K H D, and Ibrahim M F, et al. (2009) found lower correlations between all real estate securities market returns than those between the stock market returns themselves. In research by Lee C L, Stevenson S, Lee M L. (2018), the Spline-GARCH model was applied by examining securitized real estate; they found that low-frequency volatility estate securities have a strong and positive association with most of the macroeconomic risk proxies reviewed. Volatility clusters were also found in Canada (Bao H X, Huang H H, Huang Y L.,2014) and the US (Sant'Anna A C, Katchova A L.2020).

It must be highlighted that volatility clustering is also found in the housing supply (Lin Lee C, Jin X H.,2011). Apart from economic fundamentals, several factors of real estate markets, such as real estate transfer taxes (Chen H.,2017), housing market intervention based on first-time owner subsidies (Lee C L, Reed R G., 2014) and forward sales (Wong S K, Yiu C Y, Tse M K S, et al., 2006), also influence housing volatility. The impact of real estate volatility on the cost of nonnegative equity guarantees has also been examined (Huang J W, Yang S S, Chang C C.,2020).

This research shows that volatility clustering is very common in the housing market. Economic fundamentals, such as GDP, the inflation rate, and the interest rate, are critical determinants, and this positive risk-return relationship has been widely shown in housing. In the end, the recent securitized real estate and land markets show that their prices may show a change pattern similar to that for housing. However, as the review section shows, most of this research focuses on housing, and the price volatility of commercial real estate has not been examined, so our research will fill this gap. We focus on the first topic in this paper, and we will discuss the price volatility of residential and commercial real estate in Hong Kong. We will test whether there are volatility clusters in four kinds of real estate (housing, office, retail, and factory) and identify their determinants.

# Model

In this paper, we mainly examine price volatility in both residential and commercial real estate, so we choose a widely used and reliable model to identify the determinants of real estate volatility. Following Lin Lee C.'s (2009) results for Australia, we apply the ARMA-GARCH model to analyze Hong Kong real estate price data from February 1993 to February 2019. The details of this model are as follows.

First, we define the real estate price change in one period as

$$y_t = \ln(p_t/p_{t-1}) \tag{1}$$

where $p_t$ is the real estate price in period t and $y_t$ is the real asset return in period t.

Then, we use the ARMA (autoregressive moving average model) approach developed by Box and Jenkins (1976) to simulate $y_t$;

$$\mathrm{y}_t = \delta + \sum_{i=1}^{p} \emptyset_i y_{t-i} + \sum_{i=1}^{p} \theta_j \varepsilon_{t-j} + \varepsilon_t \tag{2}$$

where $\delta$ is a constant term, $\emptyset_i$ is the autoregressive coefficient, and $\theta_j$ is the moving average coefficient. $y_{t-i}$ is the asset return in a former period, and $\varepsilon_t$ is the error term at time t. p and q are the results of the autoregressive and moving average models respectively.

In Eq. 2, $\varepsilon_t$ is often assumed to have a zero mean and be homoskedastic while having a serial uncorrelated property. When the conditional heteroskedastic feature was found in the time series, Engle (1982) postponed the ARCH model to accommodate the serial correlation in volatilities that changes over time. In the ARCH model, $\varepsilon_t = \sqrt{v_t}\, z_t z_t$, which is a Gaussian white noise sequence with a mean of 0 and a variance of 1. $\mathrm{V}(\varepsilon_t/\psi_{t-1}) = v_t$, and $v_t$ is the information known before t, which is assumed to be dependent on previous errors and is estimated as

$$v_t = \varsigma_0 + \eta_1 \varepsilon_{t-1}^2 + \eta_2 \varepsilon_{t-2}^2 + \cdots + \eta_i \varepsilon_{t-i}^2 \tag{3}$$

where $\varsigma_0$ and $\eta_i$ are constant coefficients and $\varepsilon_t$ follows an autoregressive conditional heteroskedastic process of order l, expressed as ARCH(l).

The GARCH model is developed by Bollerslev (1986). In the GARCH model, the current conditional variance depends on both previous errors and previous conditional variances. The equation above is changed to

$$v_t = \varsigma_0 + \sum_{i=1}^{k} \varsigma_i v_{t-1} + \sum_{i=1}^{l} \eta_i \, \varepsilon_{t-1}^2 \tag{4}$$

Where $\varsigma_i$ are constant coefficients. In Eq. 4, $\varepsilon_t$ is said to follow a GARCH order with order k and l, written as GARCH(*k, l*). In addition, $\varsigma_i$ and $\eta_i$ should be positive, and in Eq. 4, the influence of $\varepsilon_t$ is symmetric, and positive and negative shocks to asset prices of the same magnitude produce the same amount of volatility.

As we want to know if the macroeconomic variables have an influence on real estate prices, we add the economic variable to Eq. 4 as follows:

$$v_t = \varsigma_0 + \sum_{i=1}^{k} \varsigma_i v_{t-1} + \sum_{i=1}^{l} \eta_i \, \varepsilon_{t-1}^2 + \sum \epsilon_{et} u_{economic}^2 \tag{5}$$

where $u_{economic}^2$ stands for unemployment, inflation, interest, and the Hong Kong dollar exchange rate (to USD and RMB); $\epsilon_{et}$ are variables to be observed.

We choose these economic variables for two main reasons. On the one hand, we assume that the basic economic variable has a direct influence on the real estate market, unemployment, and interest, which are seen as determinants of real estate volatility (Lin Lee C., 2009; Kok S H, Ismail N W, Lee C.,2018), and we choose inflation for the inflation-hedging effectiveness of real estate (Newell G, Lee C L, Kupke V.,2015).

According to the Mundell-Flemming model, the foreign exchange rate is of vital importance in small open economies, and its impact on real estate has also been examined in previous research (Kok S H, Ismail N W, Lee C.,2018).

However, GDP and population change (Reed R.,2016) are also important to the real estate market, but monthly data are not available for these variables, so they were not included in this analysis. The lack of these two variables limits our research.

Then, we use the EGARCH model developed by Nelson (1991) to analyze the volatility of real estate assets. The EGARCH (p, q) model is given as follows:

$$y_t = x_t' \phi + \mu_t, u_t z \sim N(0, \sigma_t^2)$$

$$log(\sigma_t^2) = \omega + \sum_{k=1}^{r} \gamma_k \frac{\mu_{t-k}}{\theta_{t-k}} + \sum_{i=1}^{p} \alpha_i \frac{|u_{t-i}|}{\sigma_{t-i}} + \sum_{j=1}^{q} \beta_j ln\sigma_{t-j}^2 \quad (6)$$

in an EGARCH(1,1) model, Eq. 7 could be written as follows:

$$log(\sigma_t^2) = \omega + \gamma \frac{\mu_{t-1}}{\theta_{t-1}} + \alpha \frac{|u_{t-1}|}{\sigma_{t-1}} + \beta ln\sigma_{t-1}^2 \quad (7)$$

If we assume $u_t \sim N(0, \sigma^2)$, then asymmetric effects can be presented as

$$ln\,(\sigma_t^2) = \begin{cases} \omega + (\alpha + \gamma) \frac{|u_{t-i}|}{\sigma_{t-i}} + \beta ln\sigma_{t-1}^2, u_{t-1} > 0, for\ good\ news \\ \omega + (\alpha - \gamma) \frac{|u_{t-i}|}{\sigma_{t-i}} + \beta ln\sigma_{t-1}^2\,, u_{t-1} < 0, for\ bad\ news \end{cases} \quad (8)$$

and in Eq. 8, $\gamma$ is the variable we want to observe. If $\gamma$ is not 0 and statistically significant, an asymmetric effect is confirmed to exist.

# Data and Preliminary Tests

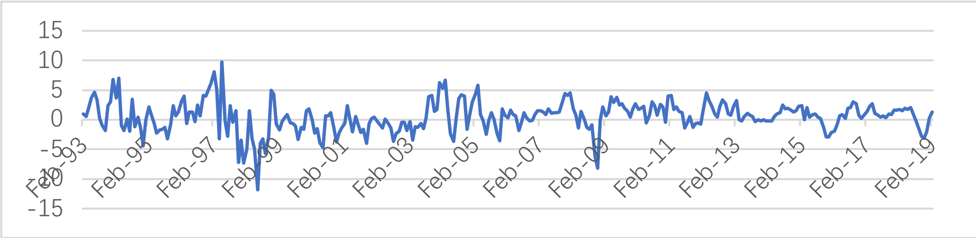
***Data***

The data we use in this paper consist of two parts. The real estate price index is from the Hong Kong Rating and Valuation Department website.[1] We use Eq. 1 to obtain the real estate price volatility, ranging from February 1993 to February 2019. Each variable is studied for 313 periods, and the basic statistics for real estate price volatility are shown in Table 1.

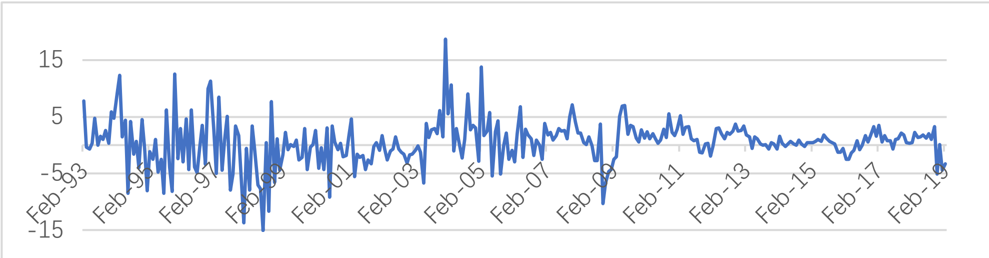
**Table 1 Basic statistics for real estate price volatility**

| | Housing | Office | Retail | Factories |
|---|---|---|---|---|
| Mean | 0.5023 | 0.4853 | 0.6040 | 0.5251 |
| Median | 0.6783 | 0.6425 | 0.6062 | 0.6901 |
| Maximum | 9.7452 | 18.7050 | 11.4127 | 10.3611 |
| Minimum | -11.8339 | -15.0862 | -14.3902 | -14.8699 |
| Std. Dev. | 2.5757 | 3.9570 | 3.3985 | 2.7969 |
| Skewness | -0.3721 | 0.0328 | -0.5683 | -0.9757 |
| Kurtosis | 5.3828 | 6.1369 | 5.6746 | 6.9407 |

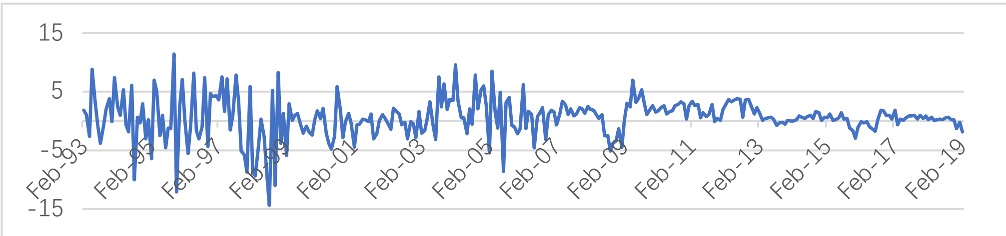
[1] https://www.rvd.gov.hk/mobile/en/index.html



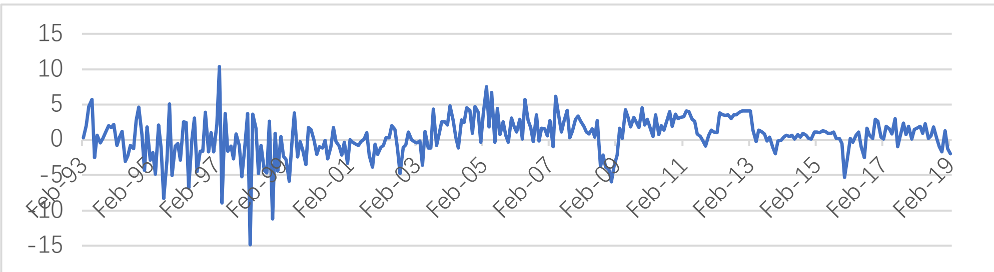

a. Housing




b. Office




c. Retail




d. Factory

**Fig 1 Real estate price volatility in Hong Kong**

As shown in Table 1, retail has the largest price change, and its variance is relatively larger than that of housing and factories. Office real estate shows a low price increase and high price volatility.

We also use data on macroeconomic variables in this paper, which include the unemployment rate, the inflation rate, the interest rate, and the change rate of the Hong Kong Dollar Exchange Rate (to USD and RMB). The basic statistics of the economic variables are shown in Table 2.

The unemployment rate and inflation rate data are from the Hong Kong statistical office website[2]; the rest are from the Hong Kong Monetary Authority[3].

[2] https://www.censtatd.gov.hk/home/

[3] https://www.hkma.gov.hk/eng

**Table 2 Basic statistics for economic variables**

| | Unemployment | Inflation | Interest rate | Exchange (USD) | Exchange (RMB) |
|---|---|---|---|---|---|
| Mean | 4.174 | 0.196 | 6.410 | 0.00456 | -0.0214 |
| Median | 3.50 | 0.20 | 5.130 | 0.00 | 0.032 |
| Maximum | 8.50 | 1.60 | 10.250 | 0.361 | 2.666 |
| Minimum | 1.50 | -1.00 | 5.00 | -0.539 | -33.35 |
| Std. Dev. | 1.608 | 0.455 | 1.714 | 0.989 | 1.979 |
| Skewness | 0.746 | -0.001 | 0.690 | -0.548 | -15.35 |
| Kurtosis | 2.725 | 3.271 | 1.878 | 9.116 | 258.95 |

### *Stationarity tests*

To analyze these time series of variables, in this paper, we use the augmented Dickey-Fuller test(ADF test) and Phillips-Perron test to determine if the real estate price series are stationary. The results are shown in Table 3.

As we can see, the results show that these four kinds of real estate prices are stationary; then, we can apply them to the ARCH model. We also test whether these independent variables are stationary; we found that the change in the Hong Kong Dollar Exchange Rate (to USD and RMB) is stationary, which is I(0).; and the unemployment rate, inflation rate, and interest rate are stationary after the first difference, which is I(1), and this result was not reported in detail.

**Table 3 The results of stationarity tests**

| | ADF test | Phillips-Perron test |
|---|---|---|
| Housing | -8.4259*** | -17.2252*** |
| Office | -5.6716*** | -18.1553*** |
| Retail | -5.5278*** | -18.1553*** |
| Factories | -5.5278*** | -17.892*** |

Notes: *Indicates significance at the 10 percent level, **indicates significance at the 5 percent level, and ***indicates significance at the 1 percent level.

## *Results*

### *ARCH effects*

To determine whether volatility clustering occurs in real estate prices, we perform an LM test before the estimation of the GARCH model. First, we use the ARMA model to simulate the real estate prices; then, we use the LM test with 12 lags, as the price data are monthly. The results of the LM test are shown in Table 4.

**Table 4 The results for ARCH effects**

| | ARMA | LM | p -value |
|---|---|---|---|
| Housing | ARMA (7,6) | 5.4163*** | 0.0000 |
| Office | ARMA (7,8) | 4.2004*** | 0.0000 |
| Retail | ARMA (7,7) | 5.8577*** | 0.0000 |
| Factories | ARMA (6,5) | 5.7477*** | 0.0000 |

Notes: *Indicates significance at the 10 percent level, **indicates significance at the 5 percent level, and ***indicates significance at the 1 percent level.

Our result shows that all four kinds of real assets exhibit volatility clustering, so we can apply the GARCH model to these four assets. As the review shows, housing volatility widely occurs in countries and regions all over the world, and our research shows that it also exists in the Hong Kong housing market.

Since our paper is the first to test the volatility cluster effect in commercial real estate, we do not know the price change pattern in commercial real estate in other cities, and further research should be done on this issue.

***Volatility determinants***

We apply Hong Kong data to this research, and the conditional mean equation is in the form of ARMA (p, q). We use the AIC/SC criterion to choose the (p, q) lag for this model. Then, GARCH (1, 1) is estimates in Eq. 5. The results are shown in Table 5.

Retail real estate shows different results. For volatility in all four assets, the coefficient of GARCH is positive and statistically significant, and the GARCH model is suitable to capture the volatility of these four kinds of real estate.

**Table 5 The results of the ARMA-GARCH model**

| **Mean Equation** | | | | |
|---|---|---|---|---|
| | Housing | Office | Retail | Factories |
| C | 0.6661*** | 0.6378** | 1.2339** | 0.8489* |
| AR(1) | 0.6095*** | 0.4611*** | 0.1360* | 0.8890*** |
| AR(2) | | 0.2641*** | | |
| MA(1) | | -0.3165** | | -0.5962*** |
| **Variance Equation** | | | | |
| C | 1.5305*** | -1.9018 | 7.3798*** | -6.1278*** |
| RESID(-1)^2 | 0.3792*** | 0.3044*** | 0.3476** | 0.4309*** |
| GARCH(-1) | 0.4589*** | 0.6861*** | 0.4673*** | 0.2157** |
| UNEMPLOYENT | -0.0808 | 0.2441** | -0.6049*** | 0.3216** |
| INFLATION | -0.102 | 0.4443 | -1.488 | 0.0122 |
| INTEREST | -0.0315 | 0.2523 | -0.2422 | 1.1513*** |
| USD | -3.5826** | -1.1654 | -13.7422** | 3.9274** |
| RMB | -0.5970*** | -0.0926 | -0.8945 | -0.4613*** |

Notes: *Indicates significance at the 10 percent level, **indicates significance at the 5 percent level, and ***indicates significance at the 1 percent level.

The results for housing determinants are very interesting; only the coefficient of the foreign exchange rate (both RMB and USD) is significant, revealing the important role that world economics play in the Hong Kong real estate market. Our finding is consistent with previous research on Hong Kong, and China's economic growth is seen as an essential factor in the Hong Kong real estate market (Leung C K Y, Tang E C H.,2015). Recent research shows that Chinese outward real estate investment has a direct influence on the Hong Kong land market and real estate prices (Li X, Hui E C M, Shen J.,2020). Our research offers evidence that the exchange rate between RMB and HKD has a significant influence on housing volatility. Regarding the USD exchange rate, Hong Kong is a small open economy, and research on Malaysia housing prices by Kok S H (Ismail N W, Lee C.,2018) showed that the foreign exchange rate plays an important role in the housing market. Our research also confirms this finding.

Commercial real estate determinants are very different from housing determinants. First, the unemployment rate is a key variable, although its influence on different types of real estate is not the same. An increase in unemployment has a negative influence on retail price volatility, which is very easy to understand. The increase in the unemployment rate negatively influences local people's income, so the retail price may suffer from a decline in shopping demand. However, its influences on offices and factories are different. Due to Hong Kong's special industry structure, financial services, tourism, trading and logistics, and professional and producer services are four key industries in Hong Kong; thus, the demand for offices and factories is mostly influenced by the global economy rather than the local labor market.

Another interesting finding is that the inflation rate has a limited influence on four kinds of real estate price volatility in the monthly data. We believe that the inflation-hedging ability of real estate is available in a gradual adjustment process (Hoesli M, Lizieri C, MacGregor B.,2008), and it will take more than a month for real estate volatility to react to an inflation change.

***Asymmetric effects***

We estimate Eq. 7 to obtain the GARCH (1,1) to find if there are asymmetric effects in the real estate market, and γ is what we want to observe. The results are shown in Table 6.

**Table 6 The results of the ARMA-EGARCH model**

| | Housing | Office | Retail | Factories |
|---|---|---|---|---|
| | -2.8978*** | -0.2494*** | -0.3192*** | -0.2475*** |
| $\omega$ | (-5.9911) | (-5.1285) | (-6.2209) | (-2.9268) |
| $\alpha$ | 0.459*** | 0.4733*** | 0.5066*** | 0.7689*** |

| | | | | |
|---|---|---|---|---|
| | (5.9917) | (5.3905) | (6.9099) | (7.8756) |
| | -0.0105 | 0.0516 | -0.0249 | 0.097 |
| $\gamma$ | (-0.2123) | (1.2145) | (-0.5189) | (1.4412) |
| | 0.9428*** | 0.9594*** | 0.9587*** | 0.7988*** |
| $\beta$ | (38.5922) | (54.5451) | (65.6943) | (18.1565) |

Notes: *Indicates significance at the 10 percent level, **indicates significance at the 5 percent level, and ***indicates significance at the 1 percent level; z-statistics are found below the coefficients.

Our results show that γ for all four real estate types is not statistically significant, and its coefficient is small. Therefore, there are no obvious asymmetric effects in the Hong Kong real estate market. According to previous research, asymmetric effects are prevalent in the housing market in some cities in Australia (Lee C L., 2009), and in Finland, asymmetric impacts of shocks on housing volatility are noted in almost all cities and subareas of housing markets (Dufitinema J,2020). However, we may assume that asymmetric impacts on real estate volatility are linked to the research area but have a lower connection to the property type. Again, further research could be done on this issue.

## Conclusion

In this paper, we applied the ARMA-GARCH model to the Hong Kong real estate market, and we test whether volatility clustering occurs in the housing, office, retail and factory real estate markets using monthly house price indices and economic variables from February 1993 to February 2019. We found that real estate volatility clustering occurs in housing, office, retail, and factory real estate in Hong Kong. The housing market,commercial real estate market and stock market have similar volatility change pattern. The volatility of housing prices is mainly influenced by the foreign exchange rate. The commercial real estate market shows differences; all are affected by unemployment. All these real estate types offer limited inflation hedging ability in a short period. The results of the EGARCH model show that there were no asymmetric effects in the real estate market.

Our research has implications for policymakers and investors. For policymakers, as housing volatility has a material impact on the stability of the financial system through the foreclosure process (Morris A Davis, 2010), it is preferable to take the influence of the foreign exchange rate on the housing market into consideration when making monetary policy, and stability in the housing market will benefit both the economy and individuals. For investors, the different determinants of real estate volatility show the potential for diversion through investing in various real estate types when building a portfolio. Previous research shows the low correlation between other securitized real estate returns (Lin Y C, Lee C L, Newell G., 2019), and our study may offer evidence about where this low correlation of real estate returns comes from.

The analysis and results are limited by the lack of data on real estate price determinants, especially monthly GDP and population data, but this problem could be solved by analyzing quarterly data in further research. We assume that asymmetric impacts on real estate volatility are heavily linked to the research area, but to date, there is limited research on different kinds of real estate volatility. Further research could be conducted to examine commercial real estate volatility.

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## *Reference*

Al-Masum M A, Lee C L. Modelling housing prices and market fundamentals: evidence from the Sydney housing market[J]. International Journal of Housing Markets and Analysis, 2019

Bao H X, Huang H H, Huang Y L. Volatility clustering in land markets[J]. Property Management, 2014.

Begiazi K, Katsiampa P. Modelling UK house prices with structural breaks and conditional variance analysis[J]. The Journal of Real Estate Finance and Economics, 2019, 58(2): 290-309.

Bollerslev T. Generalized autoregressive conditional heteroskedasticity[J]. Journal of econometrics, 1986, 31(3): 307-327.

Campbell S D, Davis M A, Gallin J, et al. What moves housing markets: A variance decomposition of the rent–price ratio[J]. Journal of Urban Economics, 2009, 66(2): 90-102.

Chau K W, MacGregor B D, Schwann G M. Price discovery in the Hong Kong real estate market[J]. Journal of Property Research, 2001, 18(3): 187-216.

Chau K W, Wong S K, Yiu C Y. Adjusting for non-linear age effects in the repeat sales index[J]. The Journal of Real Estate Finance and Economics, 2005, 31(2): 137-153.

Chen H. Real estate transfer taxes and housing price volatility in the United States[J]. International real Estate Review, 2017, 20(2): 207-219.

Christou C, Gupta R, Nyakabawo W. Time-varying impact of uncertainty shocks on the US housing market[J]. Economics Letters, 2019, 180: 15-20.

Davis M A. Reflections on the foreclosure crisis[J]. Land Lines, 2010, 2010: 1-8.

Deng Y, Girardin E, Joyeux R. Fundamentals and the volatility of real estate prices in China: A sequential modelling strategy[J]. China Economic Review, 2018, 48: 205-222.

Dufitinema J, Pynnönen S. Long-range dependence in the returns and volatility of the Finnish housing market[J]. Journal of European Real Estate Research, 2019.

Dufitinema J. Stochastic volatility forecasting of the Finnish housing market[J]. Applied Economics, 2020: 1-17.

Engle R F. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation[J]. Econometrica: Journal of the Econometric Society, 1982: 987-1007.

Ghent A C, Owyang M T. Is housing the business cycle? Evidence from US cities[J]. Journal of Urban Economics, 2010, 67(3): 336-351.

Glaeser E, Huang W, Ma Y, et al. A real estate boom with Chinese characteristics[J]. Journal of Economic Perspectives, 2017, 31(1): 93-116.

Hadavandi E, Ghanbari A, Mirjani S M, et al. An econometric panel data-based approach for housing price forecasting in Iran[J]. International Journal of Housing Markets and Analysis, 2011.

Hoesli M, Lizieri C, MacGregor B. The inflation hedging characteristics of US and UK investments: a multi-factor error correction approach[J]. The Journal of Real Estate Finance and Economics, 2008, 36(2): 183-206.

Hossain B, Latif E. Determinants of housing price volatility in Canada: a dynamic analysis[J]. Applied Economics, 2009, 41(27): 3521-3531.

Huang J W, Yang S S, Chang C C. Modeling Housing Price Dynamics and their Impact on the Cost of no-Negative-Equity-Guarantees for Equity Releasing Products[J]. The Journal of Real Estate Finance and Economics, 2020: 1-31.

Kaulihowa T, Kamati K. Determinants of house price volatility in Namibia[J]. International Journal of Housing Markets and Analysis, 2019.

Kok S H, Ismail N W, Lee C. The sources of house price changes in Malaysia[J]. International Journal of Housing Markets and Analysis, 2018.

Lai R N, Van Order R. A Tale of Two Countries: Comparing the US and Chinese Housing Markets[J]. The Journal of Real Estate Finance and Economics, 2018: 1-43.

Lai R N, Van Order R. US house prices over the last 30 years: Bubbles, regime shifts and market (in) efficiency[J]. Real Estate Economics, 2017, 45(2): 259-300.

Lam C H L, Hui E C M. How does investor sentiment predict the future real estate returns of residential property in Hong Kong?[J]. Habitat International, 2018, 75: 1-11.

Lamoureux C G, Lastrapes W D. Heteroskedasticity in stock return data: Volume versus GARCH effects[J]. The journal of finance, 1990, 45(1): 221-229.

Lee C L, Reed R G. The relationship between housing market intervention for first-time buyers and house price volatility[J]. Housing studies, 2014, 29(8): 1073-1095.

Lee C L, Reed R. Volatility decomposition of Australian housing prices[J]. Journal of Housing Research, 2013, 23(1): 21-43.

Lee C L. An examination of the risk-return relation in the Australian housing market[J]. International Journal of Housing Markets and Analysis, 2017.

Leung C K Y, Ng J C Y, Tang E C H. What do we know about housing supply? The case of Hong Kong SAR[J]. Economic and Political Studies, 2020, 8(1): 6-20.

Leung C K Y, Tang E C H. Speculating China economic growth through Hong Kong? Evidence from the stock market IPO and real estate markets[J]. International Real Estate Review, 2015, 18(1): 45-87.

Li X, Hui E C M, Shen J. The consequences of Chinese outward real estate investment: Evidence from Hong Kong land market[J]. Habitat International, 2020, 98: 102151.

Lin Lee C, Jin X H. Exploring Australian housing supply volatility[J]. Pacific rim property research journal, 2011, 17(4): 634-651.

Lin Lee C. Housing price volatility and its determinants[J]. International Journal of Housing Markets and Analysis, 2009, 2(3): 293-308.

Lin P, Fuerst F. The integration of direct real estate and stock markets in Asia[J]. Applied Economics, 2014, 46(12): 1323-1334.

Lin Y C, Lee C L, Newell G. The significance of residential REITs in Japan as an institutionalised property sector[J]. Journal of Property Investment & Finance, 2019.

Liow K H, Ho K H D, Ibrahim M F, et al. Correlation and volatility dynamics in international real estate securities markets[J]. The Journal of Real Estate Finance and Economics, 2009, 39(2): 202-223.

Miles W. Long-range dependence in US home price volatility[J]. The Journal of Real Estate Finance and Economics, 2011, 42(3): 329-347.

Miles W. Volatility clustering in US home prices[J]. Journal of Real Estate Research, 2008, 30(1): 73-90.

Miller N, Peng L. Exploring metropolitan housing price volatility[J]. The Journal of Real Estate Finance and Economics, 2006, 33(1): 5-18.

Morley B, Thomas D.2016, 'An Empirical Analysis of UK House Price Risk Variation by Property Type', Review of Economics and Finance, vol. 6, no. 2, 1923-7529-2016-02-45-12, pp.

45-56.

Nelson D B. Conditional heteroskedasticity in asset returns: A new approach[J]. Econometrica: Journal of the Econometric Society, 1991: 347-370.

Newell G, Lee C L, Kupke V. The opportunity of residential property investment vehicles in enhancing affordable rental housing supply[J]. AHURI Positioning Paper Series, 2015: 1-53.

Reed R, Wu H. Understanding property cycles in a residential market[J]. Property management, 2010.

Reed R. The relationship between house prices and demographic variables[J]. International Journal of Housing Markets and Analysis, 2016.

Reen T A, Razali M N. The dynamics of house price volatility in Malaysia[J]. Journal of Technology Management and Business, 2016, 3(2).

Sant'Anna A C, Katchova A L. Determinants of land value volatility in the US Corn Belt[J]. Applied Economics, 2020: 1-15.

Savva C S, Michail N A. Modelling house price volatility states in Cyprus with switching ARCH models[J]. Cyprus Economic Policy Review, 2017, 11(1): 69-82.

Tse R Y C. Housing return and the determinants of the capitalization rate: with reference to Hong Kong[J]. Journal of Property Research, 1996, 13(2): 115-129.

Tse R Y C. Impact of property prices on stock prices in Hong Kong[J]. Review of Pacific Basin Financial Markets and Policies, 2001, 4(01): 29-43.

Wang K, Zhou Y, Chan S H, et al. Over-confidence and cycles in real estate markets: cases in Hong Kong and Asia[J]. International Real Estate Review, 2000, 3(1): 93-108.

Wong S K, Yiu C Y, Tse M K S, et al. Do the forward sales of real estate stabilize spot prices?[J]. The Journal of Real Estate Finance and Economics, 2006, 32(3): 289-304.

Yiu M S, Yu J, Jin L. Detecting bubbles in Hong Kong residential property market[J]. Journal of Asian Economics, 2013, 28: 115-124.

## Appendix：Detailed Information on Real Estate Volatility research

| Year | Topic | Author of Study | Type | Country/Research Area | Data Frequency | Research Period | Model |
|---|---|---|---|---|---|---|---|
| **Volatility cluster in the real estate market** | | | | | | | |
| 2006 | Housing price volatility | Norman Miller, Liang Peng | Housing | 277 MSAs in US | Quarterly | 1999:Q1 to 2002:Q2 | GARCH, Panel VAR |
| 2008 | Volatility Clustering | William Miles | Housing | US 50 states | Quarterly | 1977 to 2006:Q2 | GARCH,TGARCH |
| 2009 | Housing Price volatility and its determinants | Chyi Lin Lee | Housing | Australia and 8 capital cities | Quarterly | 1997 to 2007 | ARCH, EGARCH |
| 2011 | Long-Range Dependence , Housing Price Volatility | William Miles | Housing | 100 MSAs in US | Quarterly/ Monthly | 1970s/ 1980s to 2008 | GARCH,C-GARCH |
| 2013 | Volatility clustering, risk-return relationship and asymmetric adjustment | Pin-te Lin, Franz Fuerst | Housing | Canada and 10 provinces | Monthly | January 1986 to August 2012 | ARCH, EGARCH |
| 2020 | Volatility clustering, risk-return, Asymmetric adjustment | Josephine Dufitinema | Housing | 15 main regions in Finland | Quarterly | 1988:Q1-2018:Q4, | EGARCH, GARCH-M |
| **Identify the determination of housing price volatility** | | | | | | | |
| 2007 | Determinants of housing price volatility | Belayet Hossain, Ehsan Latif | Housing | Canada | Quarterly | 1980:Q1 to 2006:Q1 | GARCH,VAR |
| 2011 | Volatility decomposition | Chyi Lin Lee, Reed Richard | Housing | Australia, Sydney, Melbourne, Brisbane, Perth, Adelaide, Hobart, | Quarterly | 1987:Q4 to 2009:Q3 | C-GARCH |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Canberra and Darwin | | | |
| 2015 | Fundamentals and the Volatility | Yongheng Deng ,Eric Girardin,Roselyne Joyeux | Housing | Beijing, Shanghai | Daily | January 2005 to December 2010 | GARCH-MIDAS |
| 2016 | Determinants of house price volatility | Tan Ai Reen , Muhammad Najib Razali | Housing | Malaysia | Quarterly | 2005:Q1 to 2013:Q4. | ARCH, GARCH |
| 2017 | Modelling house price volatility | Christos S. Savva, Nektarios A. Michail | Housing | Cyprus | Quarterly | 2001:Q1 to 2016:Q2 | SWARCH |
| 2019 | Determinants of house price volatility | Teresia Kaulihowa, Katrina Kamati | Housing | Namibia | Quarterly | 2017:Q1 to 2017:Q2 | GARCH,VAR |
| | | | **Risk-return relationship of housing** | | | | |
| 2016 | House Price Risk Variation | Bruce Morley, Dennis Thomas | Housing (four kinds) | England and Wales and its 9 regions | Monthly | January 1995 to April 2011 | EGARCH |
| 2017 | Risk-return Relationship | Chyi Lin Lee | Housing | Australia, Sydney, Melbourne, Brisbane, Adelaide, Perth | Daily | 2ed,March 2011 to 18th,May 2016 | Component-GARCH-Mean (C-GARCH-M) model |
| 2017 | Risk and Return | Steve Cook, Duncan Watson | Housing | London and several submarkets | Monthly | January 1995 to December 2015. | GARCH, EGARCH |
| 2018 | Structural Breaks and Conditional Variance Analysis | Kyriaki Begiazi, Paraskevi Katsiampa | Housing (four kinds) | UK and 13 regions or cities | Quarterly | 1993:Q4 to 2017:Q2 | conventional unit root tests， MGARCG |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2020 | Returns and volatility | Josephine Dufitinema, Seppo Pynnönen | Housing | 15 main regions in Finland | Quarterly | 1988:Q1 to 2018:Q4 | ARFIMA, ARCH |
| **Volatility research in securitized real estate and land market** | | | | | | | |
| 2008 | Correlation and Volatility Dynamics | Kim Hiang Liow, Kim Hin, David Ho, Muhammad Faishal Ibrahim, Ziwei Chen | Real estate securities | USA, UK, Japan, Hong Kong, Singapore , America, Europe, Asia | Monthly | January 1984 to March 2006 | DCC-GHR-GARCH |
| 2017 | Low-frequency volatility of real estate securities and macroeconomic risk | Chyi Lin Lee, Simon Stevenson, Ming-Long Lee | Real estate securities | Australia, France, Germany, Hong Kong, Japan, Netherlands, Singapore, Sweden, Switzerland, UK, USA. | Daily | 1st, January 1990 until 31th March 2014 | Spline-GARCH model |
| 2014 | Volatility Clustering in Land Markets | Helen Xiaohui Bao, Hui Huang , Yu-lieh Huang , Pin-te Lin | Land price | 10 province in Canada | Monthly | Panel data, 1986 to 2013 | ARCH |
| 2020 | Determinants of land value volatility | Ana Claudia Sant’Anna, Ani L. Katchova | Land Price | Corn Belt states in US(Indiana Illinois Ohio Missouri Iowa) | Yearly | 1912 to 2017 | EGARCH, Pooled VAR |