Residential housing bubbles in Hong Kong: identification and explanation based on GSADF test and dynamic probit model

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Abstract

We aim to investigate whether the current high housing price in Hong Kong contains a bubble and to identify the causes of such housing bubble if it exists by combining the generalised sup augmented Dickey–Fuller (GSADF) test and dynamic probit models. Empirical results indicate that the current Hong Kong housing market contains a bubble, and it's the investors' speculative demand and the increase of monetary supply that lead to the housing bubbles in Hong Kong. Moreover, speculative investors would prefer the mass markets to the luxury ones considering the outstanding performance of the former. Such preference would contribute to more bubbles in the mass markets than in the luxury ones. In view of these, Hong Kong Government should retrospect the linked exchange rate system and be alert to the impacts of the US monetary policies on Hong Kong residential market. To offset the housing bubble, a targeted and effective approach to the Hong Kong Government is to constrict the speculative demand from investors particularly in the mass markets.

1. Introduction

The Hong Kong residential housing market has attracted considerable attention because of its high housing price and dramatic volatility. According to Policy Address (Policy Address, 2014), the high housing price has been one of the most severe social issues in Hong Kong. The real residential housing price index has continuously increased from 107.1 in the 1st month of 2009 (2009M1) to 293.4 in the 11th month of 2015 (2015M11). These figures mean that the Hong Kong residential housing price has doubled in the past five years. Together with the high housing price is the continuously rising ratio of housing price to housing rent. By the end of 2015, the ratio of housing price to yearly rent has already reached more than 33.

In this context, it's high time to step back and ask whether the current high housing price in Hong Kong contains a housing bubble, and what leads to such bubble if it exists. Therefore, one objective of this study is to detect the existence of housing bubbles by using the generalised sub ADF test (hereafter GSADF test). Another objective of this study is to investigate the causes of the housing boom or bubble by using a dynamic probit model based on the GSADF test results.

The focus on the detection and causes of housing bubbles in the Hong Kong residential housing market is highly important. Suffering from the skyrocketing housing price, the Hong Kong community blamed the government for its insufficient residential land supply

(Hui, Leung, & Yu, 2014; Zhang, Li, Liu, & Liu, 2014). Thus, the government implemented Special Stamp Duty, plans to increase its land supply both in the long term and short term (Policy Address, 2014) and also decided to suspend the applications for Hong Kong immigration (Policy Address, 2015). Whether these policies can succeed depends on the causes of the housing boom or bubble. If the actual causes of the housing boom or bubble can be addressed, several measures can be taken to offset such boom or bubble. However, the common methods used to detect housing bubbles are often criticised for their model misspecification and failure to detect multiple bubbles (Chan, Lee, & Woo, 2001; Hui, Ng, & Lau, 2011; Hui & Yue, 2006). Moreover, previous studies on housing bubbles often focus on the causes of high housing price rather than the housing bubbles(Case & Shiller, 2003; Glaeser, Gyourko, & Saiz, 2008; Levitin & Wachter, 2011).

The contribution of this study is the combination of the GSADF test and the dynamic probit models. These two combined methods cannot only detect the housing bubbles but also investigate their causes, and thus can provide advice on relevant housing polices. This study employs the GSADF test to detect housing bubbles. Instead of focusing on the fundamental values, this GSADF test detects explosive behaviours in the housing market, and allows for changes of the original and terminate points, as well as changes of the window widths (Phillips, Shi, & Yu, 2015). These characteristics enable this method to be effective in detecting multiple bubbles and perform better than other available methods both with experimental data and real data (Pavlidis et al., 2013; Phillips, Shi, & Yu, 2014; Phillips et al., 2015). And unlike in the former studies which focus on the causes of high housing price, dynamic probit models are used in this study to determine the causes of housing bubbles based on the detection results of the GSADF test.

The remainder of this paper is organised as follows. Section 2 reviews the related literature on the detection and causes of housing bubbles. Section 3 presents the methods adopted in this study. Empirical results and discussion are illustrated in Section 4 and Section 5 concludes this study.

2. Literature review

This research concerns two types of literature, namely, studies on the identification of asset bubbles, particularly those focusing on Hong Kong's housing market, and the literature on the causes of housing bubbles.

To identify asset bubbles, there are three most extensively used tests including variance bounds tests (LeRoy & Porter, 1981; Shiller, 1980), West's two-step tests (West, 1987) and the cointegration test (Diba & Grossman, 1988). These three detection methods are all based on the theoretical foundation of the present value model. The main idea of variance bounds tests is that the observed prices should be more volatile than the variance bound imposed by the fundamental prices if an asset bubble exists. West's two-step tests mainly compare the two estimated coefficients of dividends on asset prices with or without considering a bubble, and then use the Hausman approach to test whether these two coefficients are equal. Both methods define the fundamental value and try to detect something beyond the fundamentals. However, there is still no consensus on the definition of the market fundamental value particularly in empirical studies and thus it could not be an easy task to address the existence of bubbles (Hui & Yue, 2006). In studies employing the aforementioned two methods, bubbles are theoretically defined as the deviation of the real price to the value decided by the fundamental factors (Chan et al., 2001; Hui et al., 2011; Hui & Yue, 2006). One major limitation of these two methods is that they are often criticised for the validity of their specified models; rejecting their no bubble hypothesis can be attributed to model misspecification such as an overly simple model of setting fundamental values (Gürkaynak, 2008).

Compared with the debate on the fundamental value, greater agreement has been reached on the explosive behaviour of asset price during a bubble process (Phillips et al., 2015). Instead of dealing with the market fundamental value, Diba and Grossman (1988) put forward another method, the cointegration test, to detect the existence of bubbles. This approach was mainly to test whether asset price was stationary after it was differentiated by the times of difference required to make dividends or rents stationary by using the lefttailed Dickey-Fuller tests. However, this method still has some limitations and has been criticised by Evans (1991) for its failure to detect periodically collapsing bubbles. Diba and Grossman (1988) argued that if a bubble exists at present, then it must have already existed at the beginning of the trade, while Evans (1991) introduced another possibility that the bubble could collapse to a very small value and then continue to grow. Using the simulated data generated by Monte Carlo experiments, Evans (1991) found that the method proposed by Diba and Grossman (1988) failed to detect collapsing bubbles because the collapsing behaviour was very similar with the stationary process. Phillips and Yu (2009) also reiterated that the left-tailed Dickey-Fuller statistics would be a minus infinity in the case of Evans (1991). To meet this challenge, a forward recursive right-tailed Dickey-Fuller test called sub DF test was proposed by Phillips, Wu, and Yu (2011). Thereafter, Phillips et al. (2015) developed a new test called GSADF test to improve the sub DF test which was only effective in detecting a single bubble. Phillips et al. (2015) explained that in comparison with the sub DF test, the GSADF test allows for changes of the original and terminate points, as well as changes of the window widths; thus, this new method is effective in detecting multiple bubbles in a long sample period. This method is proven to perform better than the aforementioned methods as well as Chow and CUSUM tests by experimental data generated by Monte Carlo simulations and the real data of the stock market (Pavlidis et al., 2013; Phillips et al., 2014, 2015). In recent two years, this method becomes increasingly popular to detect explosive behaviours in various markets such as housing markets (Jo & Kim, 2014; Pavlidis et al., 2013; Wan, 2015; Yiu, Yu, & Jin, 2013), oil markets (El Montasser, Gupta, Martins, & Wanke, 2015) and financial markets (Bettendorf & Chen, 2013).

Additionally, other methods such as the co-explosive vector auto regression (VAR) analysis (Engsted, Hviid, & Pedersen, 2016; Engsted & Nielsen, 2012) are also used by some scholars to detect housing bubbles. The advantage of the co-explosive VAR analysis is that it allows for the possibility that prices and rents do not have a common I(1) trend, while the GSADF test does not. However, the co-explosive VAR analysis does not allow for bursting or partially bursting bubbles within the sample period. This limitation indicates that it fails to stamp the dates of bubbles, while the date-stamping results of bubbles are quite crucial to detect the causes of housing bubbles. Besides, housing prices and rents in this study share a common I(1) trend. In the light of these above, the GSADF test is employed to detect housing bubbles and stamp their dates.

The Hong Kong residential housing market has attracted considerable attention because of its recent high housing price and dramatic price fluctuation. Since the 1997 Asian financial crisis, increasing studies have focused on detecting residential housing bubbles in Hong Kong (Chan et al., 2001; Hui et al., 2011; Hui & Yue, 2006; Xiao & Randolph Tan, 2007; Yiu et al., 2013). Chan et al. (2001) regarded the bubble part as the residual of the real housing price minus the fundamental part and the misspecification error, and their result showed that the Hong Kong housing market contained bubbles from 1990 to 1992 and from 1995 to 1997. By using a reduced form of the housing price equation, Hui and Yue (2006) detected housing bubbles in Hong Kong, Shanghai and Beijing; they estimated the sizes of housing bubbles in Hong Kong based on the estimated market fundamentals and market price. Hui et al. (2011) used West's two-step tests to detect housing bubbles; they determined the presence of bubbles before 2003 and that the luxury market also contained a bubble in 2008. However, as we mentioned before, these detection methods based on the market fundamental models are criticised for the validity of their models. Thus after the proposal of GSADF test by Phillips et al. (2015), Yiu et al. (2013) adopted this method to detect the Hong Kong housing bubble from 1993 to 2011, and they found another nine bubbles except the well-known one in 1997. Besides, they also found that the mass markets contained a bubble whereas the luxury market did not; this finding was different from that of Hui et al. (2011). However, their study has a limitation. In Phillips et al. (2015), the critical value of 95% significance level, which is used to time stamp the beginning and ending of housing bubbles, is generated by the Monte Carlo simulations with 2,000 replications.[1] In Yiu et al. (2013), however, the critical value used is defined as $CV = 1.66 + \log(rn)/100$,[2] which is a constant. Thus, the detection results of Yiu et al. (2013) may be unreliable because of the selection of a constant critical value.

To meet the aforementioned challenge, this study will also adopt the GSADF test as the detection method with the bubble definition of explosive behaviours, and select a critical value produced by 2,000 replications of the Monte Carlo simulation in accordance with Phillips et al. (2015). In addition, based on the detection results, a dynamic probit model will also be employed to determine the causes of housing bubbles in Hong Kong.

According to previous literature, the causes of housing bubble often involve demand-side factors, such as the expectations of consumers and investors (Shiller, 2008); supply-side factors, such as the inelastic housing supply caused by local regulations (Glaeser et al., 2008); credit expansion (Coleman, LaCour-Little, & Vandell, 2008; Levitin & Wachter, 2011) and the government's affordable housing policies to encourage financial institutions to extend mortgages to less qualified buyers Sowell (2009). Although there are many studies investigating the causes of housing bubbles, the most common approach is to investigate the factors that lead to the relatively high housing price compared with the housing rent or personal income, rather than the causes of housing bubbles (Case & Shiller, 2003; Glaeser et al., 2008; Levitin & Wachter, 2011). Only a few studies relied on their own detection results to investigate the causes of housing bubbles (Agnello & Schuknecht, 2011; Gerdesmeier, Reimers, & Roffia, 2010; Hott & Monnin, 2008; Kim & Suh, 1993; Shimizu & Watanabe, 2010). For example, Shimizu and Watanabe (2010) used the repeat-sales method and the hedonic method to identify the timing of bubbles in Japan and found that it was impossible to explain causes of bubbles by using demand factors. Kim and Suh (1993) employed the reduced-form model to investigate the impact of speculative demand on housing bubbles. One possible reason for the lack of research in this area is that most relevant studies are based on the market fundamental model, and the bubble part is just defined as the residual that cannot be explained by their models. Among the limited number of studies, only two are found to use the probit model to investigate the causes of asset bubbles. Gerdesmeier et al. (2010) employed a pooled probit model to investigate the causes of asset price bust by using a sample of 17 Organisation for Economic Co-operation and Development countries from 1969 to 2008. Agnello and Schuknecht (2011) also adopted this model to study the determinants of housing booms and busts with a sample of 18 countries from 1980 to 2007. However, the pooled probit model in their studies is a static approach without considering auto-correlated errors (Dueker, 2005). In addition, in the aforementioned two studies, the dummy dependent variable, which was the most important variable, was valued based on the triangular methodology which roughly compared the calculated change rate of housing price to that in the long term. To fill in the gap in literature, this study will construct dynamic probit models based on the results of GSADF test to investigate the factors that lead to housing bubbles, given the remarkable performance of GSADF test on determining the existence of bubbles in the housing market.

3. Methodology

3.1. GSADF test

Compared with the dispute of the fundamental value, greater agreement has been reached on the explosive behaviour of asset price during the bubble process. To conduct the GSADF test, several steps are quite essential, including determining the formulation of hypothesis, selecting the lag length and stamping dates of bubbles.

The null hypothesis of the GSADF test, which is designed to detect the explosive behaviour, is $\delta = 1$with the alternative one of $\delta > 1$ in Equation (3.1).

$$y_t = dT^{-\eta} + \delta y_{t-1} + \varepsilon_t \qquad (3.1)$$

In Equation (3.1), y_t is defined as the ratio of housing price to housing rent, and T is the sample while d and η are constants with $\eta \geq .5$. Phillips et al. (2015) explained that transient dynamics should be added to Equation (3.1) to test the explosive behaviour of this ratio. According to Phillips et al. (2015), η is a parameter which controls the magnitude of the intercept and the drift with $T \rightarrow \infty$. In this study, we set $d = 1$ and $\eta = 1$ since Phillips et al. (2015) argue that the distribution of ADF statistics is insensitive to changes as long as $\eta \geq .5$. One prominent characteristic of this method is the ability to change the initial and terminate dates. Thus, the method is an ADF style test with a rolling and flexible window. The initial window size of $r_0 = .1$ is used with 27 observations.[3] Suppose that the starting point of the rolling and flexible window is the $r_1 th$ of the entire sample and its ending point is the $r_2 th$[4] faction. Thus, Equation (3.1) can be rewritten as Equation (3.2).

$$\Delta y_t = \hat{\alpha}_{r_1,r_2} + \hat{\beta}_{r_1,r_2} y_{y-1} + \sum_{i=1}^{k} \hat{\psi}^i_{r_1,r_2} \Delta y_{t-i} + \hat{\varepsilon}_t \qquad (3.2)$$

In Equation ($r_2$3.2), k is the lag length. In this regression, the simple size is $T_w = r_w T$. To obtain

ADF_{r_1} based on Equation (3.2), the next step is to select the optimal lag length in order to enable ε_t to denote white noise and be uncorrelated. The most widely used methods of selecting the lag length include Akaike information criterion (AIC) (Akaike, 1973), Schwarz bayesian information criterion (SIC) (Schwarz, 1978), modified AIC (MAIC) and modified SIC (MSIC). Both SIC and AIC are criticised for their low effectiveness, particularly when the sample size is small. Thus, considering the limited sample size of Equation (3.2), MSIC is employed to determine optimal lag length.

To date stamp the starting and ending points of bubbles in the sample period, Phillips et al. (2015) calculated $BSADF_{r_2}(r_0)$ by employing a backward expanding sample sequence. The date-stamping strategy is that a bubble starts when this statistics exceeds the critical value. And a bubble ends when this statistics is under the critical value. Readers who are interested in this method are advised to refer to Phillips et al. (2015).

3.2. Dynamic probit model

A probit model is often used when the dependent variable is a limited dependent variable (the value is zero or one) (Brandt, Rozelle, & Turner, 2004; Jin & Deininger, 2009). Considering the auto-correlated errors, a dynamic probit model is employed in this study based on the results of the detection part, to investigate the causes of housing bubbles. When the detection result shows that the testing statistics exceeds the critical value, the dependent variable is set at equal to one, meaning that there exists a bubble at that specific point. When the detection result shows that the testing statistics is less than the critical value, the dependent variable is set at equal to zero, meaning that there does not exist a bubble just as the following Equation (3.3) shows.

$$y_t = \begin{cases} 1, & BSADF_t \geq CV_t \\ 0, & BSADF_t < CV_t \end{cases} \qquad (3.3)$$

$$P(y_t = 1) = \Phi(\alpha + X_t\beta) = \Phi(\pi_t) \text{ where } \pi_t = \alpha + X_t\beta \qquad (3.4)$$

Equation (3.3) and Equation (3.4) show the static probit model. Kauppi and Saikkonen (2008) elucidated that a general equation of dynamic probit model should be extended, as shown in Equation (3.5).

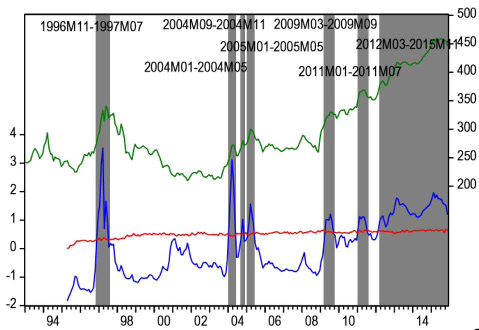
$$P(y_t = 1) = \Phi(\alpha + \sum_{i=1} \eta_i y_{t-i} + X_t\beta) \qquad (3.5)$$

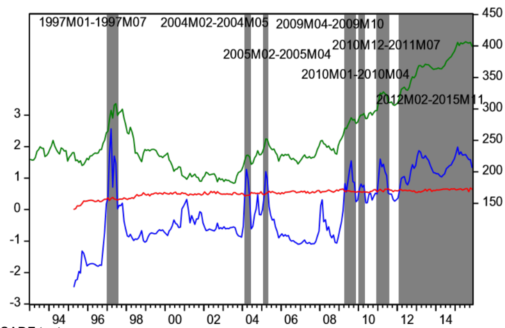
In Equation (3.5), m stands for the lagged orders of y_t. No theoretical guide shows how to select the form and lagged orders of dynamic probit model. Thus, several attempts are made to acquire the optimal model.

4. Empirical results

During the past two decades, several fluctuations can be easily observed in Hong Kong's housing market (see Figure 1). For example, from 1993 to 1997, Hong Kong experienced a housing boom. The real housing price index doubled during the four years, increasing from
84.4 in 1993 to 172.9 in 1997. However, after the Asian financial crisis in 1997, Hong Kong's

GSADF test





GSADF test

Bacwards SADF seq
axis)
95% critical value sec
axis)
ENTIRE (right axis)

Bacwards SADF sequence (left axis)
95% critical value sequence (left axis)
CLASS_A (right axis)

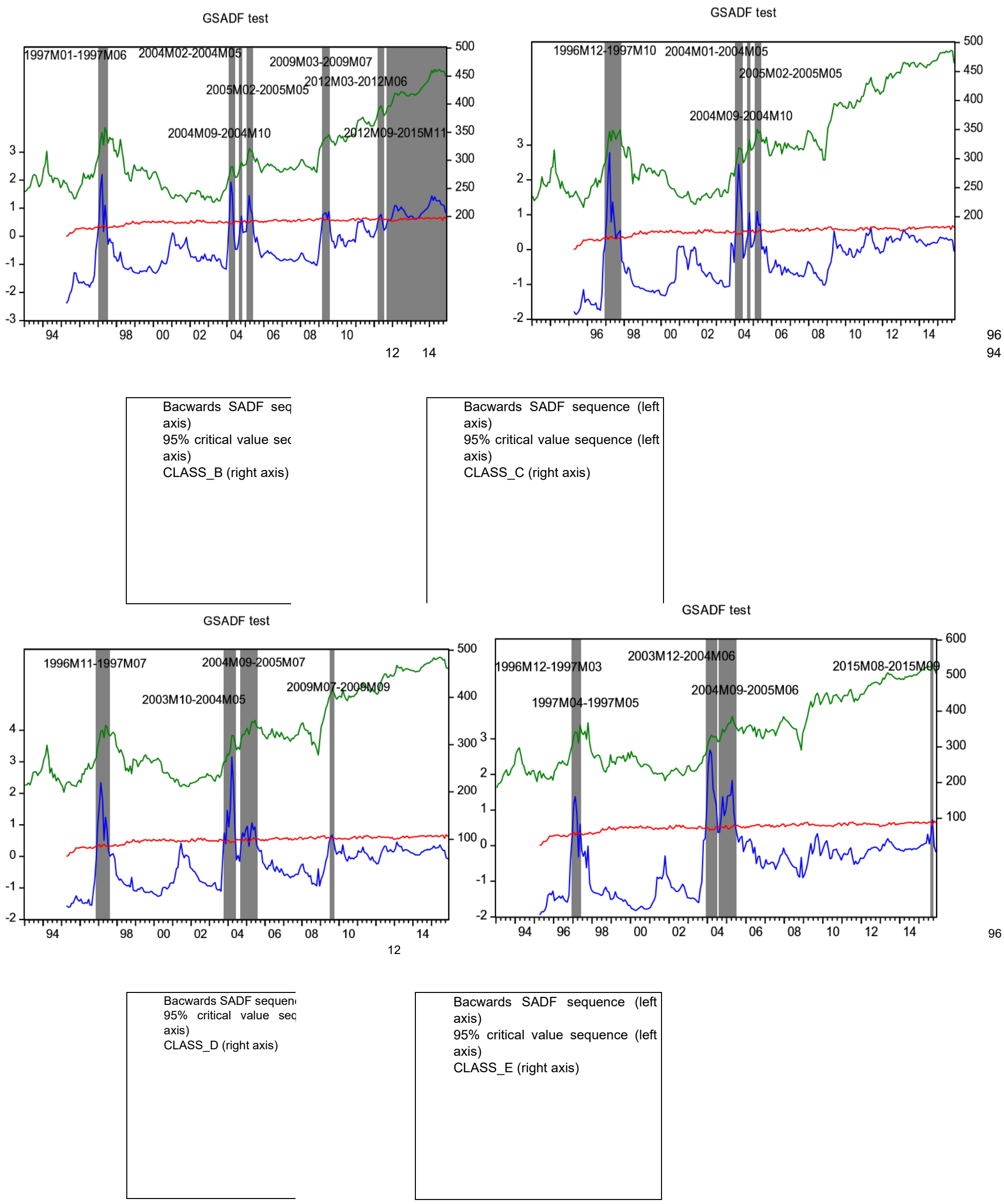


Figure 1. Identified bubble periods in the housing price to rent ratio for the entire market, and markets of class a to class e.

notes: this figure presents the changes of the ratio of housing price to rent (green line), the backwards saDf sequence (blue line) and the critical value of 5% significance level (red line). a shadow area is drawn when the testing statistics is greater than the critical value, which means a bubble is present. the top left panel represents the entire hong Kong housing market, and the top right panel represents the market of class a. the middle left panel represents the market of class B, and the middle right panel represents the market of class c. the bottom left panel represents the market of class D, and the bottom right panel represents the market of class e.

housing market depression began and the housing price kept continuously decrease. The real housing price index experienced a significant decline, dropping from 172.9 in 1997 to 58.6 in 2003. After 2003, the housing market began another boom and the housing price entered a fast ascending period. The real housing price index increased from 58.6 in 2003 to 126.6 in 2008. In 2008, the sub-prime mortgage crisis exposed and the housing market experienced a short-term decline, with the real housing price index decreasing to 104.8 at the beginning of 2009. After that, a rapid recovery was observed in Hong Kong's housing market. By 2015, the real housing price index had already reached around 300.

Besides, to intervene in the housing market, Hong Kong Government also implemented a variety of policies including land supply policies, the Investment Immigration Policy, Free Independent Travel Programme and Stamp Duty Policy (see Table 5). For example, during the Asian Financial Crisis, Hong Kong Government decided to suspend its regular land auctions, set up Mortgage Insurance Programme and cancel the anti-speculative measure to stimulate the housing market. However, with the skyrocketing housing price in recent years, Hong Kong Government implemented Special Stamp Duty, and suspended the Investment Immigration Policy to further regulate the housing market.

The dramatic volatility and institutional changes in Hong Kong's housing market has made an ideal case study for detecting and analysing housing bubbles (Funke & Paetz, 2013; Huang, Shen, & Zheng, 2015).

4.1. Detection

The data-set we use for the GSADF test, which is obtained from CEIC Data's global database, contains monthly observations in the Hong Kong housing market from the 1st month of 1993 (1993M1) to the 11th month of 2015 (2015M11). Monthly observations include real

Table 1. Descriptive statistics of price-rent ratios for housing markets of different classes.

	Class A	Class B	Class C	Class D	Class E	Entire
Mean	258.9529	308.3499	327.1477	320.5306	337.6842	295.7392
Median	235.2018	287.6508	316.4895	312.1023	330.0513	269.494
Maximum	406.7899	462.077	486.4193	485.298	530.4368	459.1183
Minimum	181.9156	225.193	215.9624	199.4152	186.6667	209.8033
std. Dev.	60.17074	63.1855	80.53741	85.37953	98.92242	67.32366
skewness	.988856	.862333	.54269	.482828	.410669	.944219
Kurtosis	2.892724	2.743923	2.012132	1.918017	1.844392	2.82313
Jarque-Bera	44.94937	34.83388	24.68049	24.09894	23.03155	41.22116
observations	275	275	275	275	275	275

notes: In this table, we report the results of descriptive analysis for various types of markets. Descriptive statistics include the sample mean, median, maximum, minimum, standard deviation (std. Dev.) skewness, kurtosis, Jarque-Bera and the sample size.

Table 2. testing statistics and critical values of GsaDf test at significance levels of 1, 5 and 10%.

	Price to rent	99%CV	95%CV	90%CV
class a	3.3713***	2.9497	2.2781	1.9976
class B	2.2486*	2.9497	2.2781	1.9976
class c	2.7864**	2.9497	2.2781	1.9976
class D	3.1546***	2.9497	2.2781	1.9976
class e	2.6836**	2.9497	2.2781	1.9976
entire	3.6212***	2.9497	2.2781	1.9976

note: In this table, we report the testing statistics of price-rent ratios for all market segments and the entire market, as well as the critical values at 1, 5 and 10% significance levels. $^{*}p < .1$; $^{**}p < .05$; $^{***}p < .01$.

housing prices and real housing rents. A ratio of real housing price to real housing rent is constructed to investigate whether the real housing price is explosive compared with the fundamentals (the housing rent). In addition, Hui et al. (2011) reported a difference between the mass markets[5] and the luxury markets,[6] and argued that the luxury markets experienced more bubbles within the same sample period. To examine the existence of such difference between different market segments in the frequency of bubble occurrence, ratios of real housing price to real housing rent of Class A,[7] Class B,[8] Class C,[9] Class D[10] and Class E[11] are also constructed. Table 1 presents the results of the descriptive analysis for the price-rent ratios constructed for all market segments and the entire market.

Table 2 presents the empirical results of applying the GSADF test on the entire Hong Kong residential market and residential market segments. The testing statistics of Class D and the entire residential market are greater than the critical value at 1% significance level, while those of Class A, Class C and Class E are greater than the critical value at 5% significance level. Although the testing statistics of Class B is less than the 95% critical value, the p value of Class B is .052 (close to .05). Therefore, the null hypothesis of no bubbles is rejected, and explosive behaviours in the ratios of housing price to rent are determined both in the market segments and the entire Hong Kong market.

Detection results of the cointegration test[12] are compared with those of GSADF test (see Table 3). The cointegration test statistics of first-order differenced housing prices[13] for all markets and the entire market are significant, which indicates the housing prices are stationary after first difference. According to Table 3, it can be concluded that results of the cointegration test reject the existence of housing bubbles for all the market segments and the entire market, while results of GSADF tests support the existence of housing bubbles. Just as Evans (1991) argued, the cointegration test fails to detect periodically collapsing bubbles. During our sample period from 1993 to 2015, several collapsing bubbles can be observed in Figure 1.[14] Therefore, results of GSADF tests are superior to those of the cointegration test. Our detection results support the argument of Evans (1991).

Our empirical evidence supports the existence of bubbles. Figure 1 shows the results of date stamping of bubbles. For the entire residential housing market in Hong Kong, seven bubbles[15] are identified by the GSADF test. Yiu et al. (2013) claimed that ten bubbles were detected during their sample period from 1993 to 2010, while in our study only five bubbles were detected during the same period by using a critical value generated by 2000 replications of Monte Carlo simulation. Another one notable finding of the detection results, different from Yiu et al. (2013), is that the entire residential market in Hong Kong currently contains

Table 3. testing results of GsaDf test and cointegration test for housing markets of different classes.

Testing statistics	Class A	Class B	Class C	Class D	Class E	Entire
GsaDf test	2.5663**	2.1999*	2.7864**	3.1546***	2.6836**	3.5396***
cointegration test	−5.92697***	−4.560056***	−7.08165***	−7.634704***	−8.738034***	−4.775218***
observations	275	275	275	275	275	275

notes: In this table, results of the GsaDf test and the cointegration test for all market segments and the entire market are reported. the GsaDf test employs the testing statistics of price-rent ratios for all markets segments and the entire market. the cointegration test uses the unit root test statistics of the first-order differenced housing prices for all markets segments and the entire market, since their housing rents are I(1). $^{*}p < .1$; $^{**}p < .05$; $^{***}p < .01$.

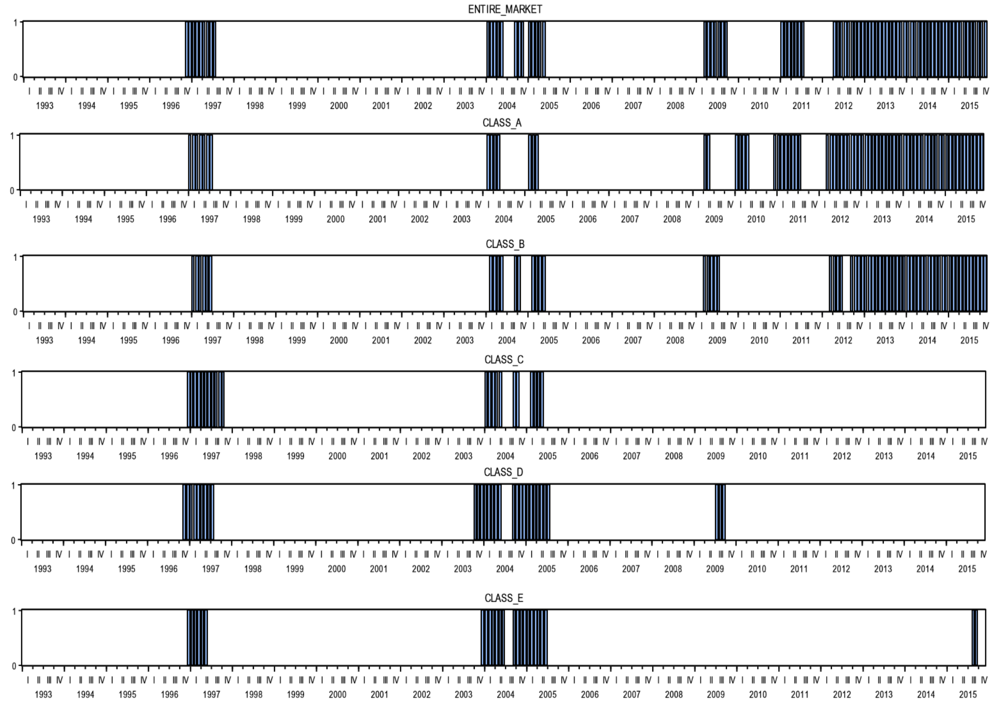


Figure 2. Bubble synchronisation for the entire market and markets of class a to e.
notes: coloured areas in this figure indicate the bubble periods identified by GsaDf test at a 5% significance level. the mass markets including class a, class B and class c contain more bubbles than the luxury markets including class D and class e during the sample period.

a bubble. Phillips et al. (2015) also explained that GSADF test can be not only regarded as a detecting method but also a warning system. This finding turns our attention towards the causes of the current bubble if several measures will be implemented to offset this bubble. For the Hong Kong market segments, seven bubbles[16] are identified for the Class A market; seven bubbles[17] are identified for the Class B market; four bubbles[18] are identified for Class C; four bubbles[19] are identified for Class D and five bubbles[20] are identified for Class E. The numbers of bubble periods detected for residential market segments are also below those in Yiu et al. (2013). Figure 2 is graphed to investigate the difference between housing market segments in the frequency of bubble occurrence. From Figure 2, it can be concluded that the mass markets experience more bubbles than the luxury ones during the sample period. This finding, which is different from Hui et al. (2011) but consistent with Yiu et al. (2013), also guides further investigation on factors that lead the difference between the different market segments in terms of the frequency of bubble occurrence.

4.2. Causes

Probit models are conducted based on the results of the GSADF test to investigate the causes of housing bubbles. According to Phillips et al. (2015), GSADF test has been proven to be one of the most effective detection methods, particularly in the long sample period. This characteristic enables the use of a dynamic probit model to further investigate the causes of housing bubbles. From previous studies, the causes of housing bubbles mainly involve the following factors: speculative demand of consumers and investors (Shiller, 1980), inelastic housing supply (Glaeser et al., 2008) and credit expansion (Coleman et al., 2008; Levitin & Wachter, 2011). Considering the possible effects of the Investment Immigration Policy and Individual Visit Scheme on housing market, dummy variables related to these policies should also be included. The Hong Kong Yearbook (2003) stated that the Hong Kong Government launched the Capital Investment Entrant Scheme in October 2003; this publication stipulated that to immigrate to Hong Kong, foreigners should invest at least HK$ 6.5 million on financial products or real estate. In October 2010, the Hong Kong Government tightened this immigration policy and reset the eligibility criteria to at least HK$ 10 million on financial products. Investment on real estate properties was excluded. Considering this institutional change during the sample period, two dummy variables for the Investment Immigration Policy are used in the model.

The data-set used for probit models is obtained from CEIC Data's global database. It contains monthly observations of the interpretations of the GSADF results and potential housing bubble causes. Table 4 presents the selected variables, their definitions and descriptive statistics. For independent variables, the speculative demand from investors is measured by the myopic expectation of housing price changes[21]; two interactive variables of speculative demand and Special Stamp Duty are constructed to examine the effects of Special Stamp Duty on speculative demand; income level is measured by median monthly earnings with bonus; housing supply is measured by private new completions to be consistent with Glaeser et al. (2008), where housing permits are served as their measure of new quantity; mortgage expansion is measured by the mortgage consented by banks per month; monetary policies taken by government is measured by money supply (M2); mortgage rate is measured by bank lending rate; to intervene in the economy and the housing market, Hong Kong Government implemented a variety of policies such as the Investment Immigration Policy, Free Independent Travel Programme, and Stamp Duty Policy. Table 5 presents those related policies taken by government from 1993 to 2015 and also their classification results.[22] To investigate the factors that lead to the present housing bubble so that measures can be implemented to offset the current bubble, all of these types of factors will be incorporated into the dynamic probit model.

Before the construction of probit models, the ADF test is employed to assess whether the dependent variable and independent variables (excluding dummy variables) are stationary. Table 6 presents the results of the ADF test. It can be concluded that all tested variables are stationary, except for the income level (stationary after the first-order difference), the money supply (stationary after the first-order difference) and the bank lending rate (stationary after the first-order difference). Therefore, these three non-stationary variables will be incorporated into the present model after the first-order difference, while other stationary variables will be included directly.

Both a static and dynamic probit models are constructed to evaluate the robustness of the results of this study. All models are estimated by using maximum likelihood. White robustness variances are used for the statistical inference.[23] Table 7 shows the results of both static and dynamic probit models. McFadden R square increases from .451 to .801 and the AIC decreases from .753 to .337 when one-month lagged dependent variable is incorporated into the static model. Hence, the dynamic probit model is superior to the static one. To construct a dynamic probit model, the next step is to determine the lagged order. Model

Table4. Variableselectionanddescription.

Category		Variablename	Variabledefinition	Mean	Standarddeviation
Dependentvariable		y	,ifthetestingcriticalvalueisgreaterthanthe95% cV,meaningthe existenceofbubbles,and0otherwise.	.294118	.456485
IndependentVariable	Demandforces	sD	expectationofhousingpricechangesmeasuredbymyopicexpectation. (%)	.004899	.026982
		sD*ssD_1	Designedtoexaminetheeffectof specialstampdutyin2010onspec - ulativedemand.ssD_1equals1ifthecurrentspecialstampdutyis consistentwiththeonein2010,and0otherwise.	.084559	.278737
		sD*ssD_2	Designedtoexaminetheeffectof specialstampdutyin2012onspec - ulativedemand.ssD_2equals1ifthecurrentspecialstampdutyis consistentwiththeonein2012,and0otherwise.	.139706	.347321
		1			
		Il	Incomelevelmeasuredbymedianmonthlyearningswithbonus.(hK$)	10,394.27	1486.59
	supplyforces	hs	housingsupplymeasuredbynewcompletionspermonth.(unit)	132,649	122,395.4
	financialforces	Me	Mortgageexpansionmeasuredbythemortgageconsentedbybanksper month.(million)	11,659.9	4105.03
		Ms	Monetarypoliciesmeasuredbymoneysupply(M2).(hKmillion)	5,046,513	2,759,725
		rate	Mortgageratemeasuredbybanklendingrate.(%)	6.607273	1.741318
	otherPolicies	IIP_1	,ifthecurrentInvestmentImmigrationPolicyisconsistentwiththe immigrationpolicyin2003,and0otherwise.	.308824	.46286
		IIP_2	,ifthecurrentInvestmentImmigrationPolicyisconsistentwiththe immigrationpolicyin2010,and0otherwise.	(.191176	.393953
		IVs (	IndividualVisitschememeasuredbythenumberofindividual chinese visitorsofthisscheme.	684,401.9	871,389.4

notes:Inthistable,wereportvariablesselectedfortheprobitmodelandtheirdescriptions. thesevariablesincludethedependentvariable(y,speculativedemand sD),theinteractivevariableof speculativedemand(sD)and specialstampDutyof2010(ssD_1),theinteractivevariableofspeculativedemand(sD)and specialstampDutyof2012(ssD_2),incomelevel(I I ,housingsupply (hs ,mortgageexpansion(M e,moneysupply(M s,banklendingrate rate ,InvestmentImmigrationPolicyof2003(IIP_1),InvestmentImmigrationPolicyof2010(IIP_2)andIndividualVisit scheme(IVs).

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Table 5. classification results of policies related to hong Kong housing market (1993M1 to 2014M12).

Date	Policies	Speculative demand	Mortgage expansion	Housing supply	Other policies
1993M6	Mortgage ceiling decreased from 90% to 70%.		√		
1994M6	anti-speculation measures were taken.	√			
1995M2	Priority mortgage rate increased to 10.24%.		√		
1998M2	Duty for mortgage repayment interest was free.		√		
1998M5	anti-speculation measures were cancelled.	√			
1998M6	land auctions were suspended.			√	
1999M2	85% Mortgage Insurance Programme was set up.		√		
1999M4	land auctions were resumed.			√	
2000M2	anti-speculation measures were relaxed.	√			
2002M11	land auctions were suspended.			√	
2002M11	two anti-speculation measures were cancelled including limiting internal subscription and each buyer only purchasing one residential property.	√			
2002M11	Priority mortgage rate decreased to 5%.		√		
2003M6	Individual Visit scheme was started.				√
2003M10	Investment Immigration Policy was implemented.				√
2006M3	Priority mortgage rate increased to 8.25%.		√		
2007M2	stamp duty for property between 1 million and 2 million hK$ decreased to 100 hK$.	√			
2010M11	special stamp Duty was implemented.	√			
2012M10	special stamp Duty rate increased by 5% and the restriction period extended from 2 to 3 years. Buyer's stamp Duty was imposed.	√			
2015M1	Investment Immigration Policy was suspended.				√

note: In this table, we report policies taken during the sample period which are related to the housing market, as well as the classification results of these policies.

1–4 are constructed to determine the lagged order of the dependent variable. Considering the significantly decreasing McFadden R square as well as the fact that most dependent variables are valued by zero, the lagged order of dependent variable is set to be one month.[24] Model 5 only incorporates the one-month lagged independent variable, whereas Model 6 incorporates both the lagged dependent and the lagged independent variables. After incorporating the lagged dependent variable in Model 6, the coefficient of the one-month lagged speculative demand (which is significant in Model 5) is no longer significant. Therefore, the lagged independent cannot offer any additional information on predicting the housing bubble if the lagged dependent variable is incorporated. Furthermore, the coefficients of lagged independent variables in Model 6 are not significant and its AIC is greater than that of Model 1, although the McFadden R square of Model 6 slightly exceeds that of Model 1. Therefore Model 1 is selected as the final model based on the current analysis.

Our empirical results show that from a dynamic viewpoint, it's the speculative demand from investors and the change of money supply that lead to the current housing bubble in Hong Kong, given that only the coefficients of these two independent variables are significant. The possibility of housing bubble occurrence will increase with the growth of speculative demand from investors and the money supply while the housing supply, mortgage expansion, mortgage rate, the Individual Visitor Scheme and the Investment Immigration Policy have no influence on the possibility of the housing bubble occurrence. Considering that estimated coefficient from a probit model cannot be interpreted as the

Table 6. aDf tests of variables.

	Critical value				
Variable name	1%	5%	10%	Testing statistics	Prob
y	−3.454085	−2.871883	−2.572354	−3.944884	.0020
hs	−3.454353	−2.872001	−2.572417	−14.25337	.0000
Il	−3.454626	−2.872121	−2.572482	.305458	.9783
IVs	−3.455486	−2.872499	−2.572684	−3.406449	.0116
Me	−3.454174	−2.871922	−2.572375	−3.981313	.0018
Ms	−3.454085	−2.871883	−2.572354	3.444539	1.0000
sD	−3.454174	−2.871922	−2.572375	−8.951904	.0000
rate	−3.454353	−2.872001	−2.572417	−2.088935	.2494
D(Il)	−3.454626	−2.872121	−2.572482	−9.057636	.0000
D(Ms)	−3.454174	−2.871922	−2.572375	−16.3446	.0000
D(rate)	−3.454353	−2.872001	−2.572417	−4.747020	.0001

notes: this table summarises the results of aDf test of variables which include the dependent variable (y), housing supply (hs), income level (Il), number of individual chinese visitors (IVs), mortgage expansion (Me), money supply (Ms), speculative demand (sD), bank lending rate (rate), income level after the first-order difference (D(Il)), money supply after the first-order difference (D(MP)) and bank lending rate after the first-order difference (D(rate)).

marginal effect of its corresponding variable, the ratio of coefficients is constructed to measure the relative changes in the probabilities. The ratio of the coefficient of speculative demand to the coefficient of the change of money supply indicates that the possibility of housing bubbles is more sensitive to the speculative demand.

It is also noted that the coefficients of the interactive variables of speculative demand and Special Stamp Duty are not significant, indicating Special Stamp Duty failed to curtail investors' speculative activities. Another finding is that Investment Immigration Policy has no influence on the possibility of bubble occurrence. Suffering from the high housing price, Hong Kong Government launched the Special Stamp Duty policies in November 2010 and October 2012, and it decided to suspend the applications for Hong Kong investment immigration in January 2015 in order to offset the high housing price (Policy Address, 2015). However, according to our empirical findings, all of those policies would fail to affect the possibility of the current bubble concurrence in the entire Hong Kong market.

Our empirical results indicate that it's the increase of money supply caused by the linked exchange rate system and the speculative demand from investors that lead to the housing bubble in Hong Kong. In Hong Kong, the linked exchange rate system of Hong Kong dollar to the US currency was set up in 1983 at the exchange rate of 7.8 Hong Kong dollars to one US dollar and it is still in use. Under this exchange-rate regime, Hong Kong Government in fact loses its independence of monetary policies. The US Government has increased its money supply for seven years by taking several rounds of quantitative easing[25] as well as implementing zero-interest rate policy since the subprime crisis in 2008. To keep the linked exchange rate system of Hong Kong dollar to the US currency, Hong Kong Government compelled itself to issue corresponding paper money. When the Hong Kong Government increases its money supply to stabilise the exchange rate of Hong Kong dollar to the US currency, investors would turn to the asset markets for their purposes of preserving principal, which would serve as a positive demand shock to the housing market, and encourage an initial increase of housing price. And then a positive feedback is noted between the increasing housing price and the speculative demand, which would eventually lead to the generation of bubbles. This lack of effective and independent monetary policies would lead Hong Kong to experience serious negative interest rates and increase the fluctuation of property prices (Tse, 1994). Gerlach and Peng (2005) also argued that under the currency board regime,

Table 7. Empirical results of probit models.

	Static model	Dynamic models					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
C	−2.415486***	−1.631771**	−1.880199***	−2.029903***	−1.979942***	−2.865115***	−2.459835*
SD	24.80106***	28.56066***	36.84379***	30.57881***	29.41171***	19.52464***	29.05516**
SSD_1*SD	.229885	32.56973	21.26122	21.52638	20.83082	−23.1117	13.063
SSD_2*SD	5.766007	1.966339	−5.932522	−.914324	.781554	−35.28887	−21.89675
D(IL)	−.001097	.001375	−.001263	−.001285*	−.001991**	−.000565	.001435
HS	−5.72E-08	−2.40E-06	−4.30E-07	5.62E-08	−5.72E-07	−1.87E-06	−3.48E-06
D(MS)	1.02E-06	3.04E-06***	2.14E-06**	2.22E-06**	2.26E-06**	1.67E-06	4.00E-06*
D(RATE)	2.252125***	.996409	.736597	.465077	.694291	2.291903	1.262566
ME	5.23E-05*	−6.38E-05	−4.45E-05	−1.37E-05	2.03E-07	.00013*	−6.35E-05
IIP_2003	−.221352	−.20785	−.332105	−.210138	−.257777	−6.11137	−5.913222
IIP_2010	−.150019	−.49731	−.371221	−.107273	−.158305	−13.09322	−11.36969
IVS	1.35E-06***	2.50E-07	5.65E-07**	6.76E-07***	7.72E-07***	9.35E-07	−3.08E-07
Y(-1)		3.738663***					3.885757***
Y(-2)			2.859526***				
Y(-3)				1.988189***			
Y(-4)					1.66181***		
SD(-1)						38.91278***	27.21656
SSD_1*SD(-1)						6.760783	5.463005
SSD_2*SD(-1)						47.06361	20.6768
D(IL)(-1)						−.001287	−.001701
HS(-1)						1.46E-07	1.33E-06
D(MS)(-1)						5.56E-07	−2.63E-06
D(RATE)(-1)						2.259077	.838303
ME(-1)						−8.91E-05	1.30E-05
IIP_2003(-1)						5.634721	5.785862
IIP_2010(-1)						12.94583	11.44262
IVS(-1)						7.35E-07	8.28E-07
McFadden R-squared	.451357	.8008	.698127	.588978	.547222	.59239	.841515
Akaike info criterion	.752969	.336938	.461336	.59358	.645383	.664372	.369442
LR statistic	148.7463 ($p < .01$)	263.9067 ($p < .01$)	230.0704 ($p < .01$)	194.1 ($p < .01$)	179.957 ($p < .01$)	194.8109 ($p < .01$)	276.7369 ($p < .01$)

Notes: In this table, we report the empirical results of both static and dynamic probit models, which include the coefficients of selected variables, LR statistics, AIC and Pseudo R square. C represents constant; SD and SD(-1) represent speculative demand and its one-month lagged variable; ME and ME(-1) represent mortgage expansion and its one-month lagged variable; HS and HS(-1) represent housing supply and its one-month lagged variable; Change rate of IVS and Change rate of IVS(-1) represent the change rate of number of individual Chinese visitors of Individual Visitor Scheme and its one-month lagged variable; IIP_1 and IIP_1(-1) represent Investment Immigration Policy of 2003 and its one-month lagged variable; IIP_2 and IIP_2(-1) represent Investment Immigration Policy of 2010 and its one-month lagged variable; Y, Y(-1), Y(-2), Y(-3) and Y(-4) represent the dependent variable and its one-month, two-month, three-month and four-month lagged variables, respectively.

$^{*}p < .1$; $^{**}p < .05$; $^{***}p < .01$.

Table 8. Description of housing price changes for different classes.

	Class A	Class B	Class C	Class D	Class E
Mean	.25%	.26%	.30%	.33%	.45%
Median	.31%	.30%	.37%	.17%	.45%
Maximum	7.22%	9.34%	10.23%	13.25%	16.57%
Minimum	−9.05%	−11.87%	−13.62%	−12.16%	−15.52%
std. Dev.	2.39%	2.72%	3.14%	3.32%	4.20%
skewness	−.28287	−.009159	−.106209	.2134	.377025
Kurtosis	4.176675	5.176924	5.479185	5.182375	5.119689

notes: In this table, we report the descriptive statistics of housing price change rates for all market segments, including the mean, median, maximum, minimum, standard deviation (std. Dev.), skewness and kurtosis.

monetary policies cannot be used to guard asset swings since interest rates are determined by US monetary policies. In view of this finding, Hong Kong Government should be alert to the possible housing price collapse brought by the recent tightened monetary policies taken by the US Government.[26] Theoretical support can also be found for this finding in the form of the adaptive expectation model (DiPasquale & Wheaton, 2002).

The aforementioned difference between the housing market segments in terms of the frequency of bubble occurrence can be explained based on our empirical findings. Both speculative demand and the money supply can be defined as demand-side factors, since the money supply increases the housing demand for investors' goal of preservation and increment. In other words, the empirical results indicate that it's the demand force, particularly the speculative demand from investors,[27] that determines whether the Hong Kong housing market contains a bubble. Thus, we conduct a descriptive analysis of what speculative investors concern the most – the performance of each market segment – to investigate the causes of such difference between the housing market segments in the frequency of bubble occurrence (see Table 8). The luxury markets are more fluctuant with greater deviation than the mass markets. In other words, the luxury ones contain considerable risks. Compared with the luxury ones, the mass markets perform much stably and pretty well with high means and smaller deviations. Investors have to strike a balance between these higher returns and higher risks. Among the mass markets, the Class A housing market performs with a high mean and the smallest deviation. Hence, speculative investors would prefer to the Class A market. Class B comes second and Class C comes last. Moreover, the means of Class D and Class E are greater than their medians, while the means of Class A, Class B and Class C are less than their medians. The skewnesses of both Class D and Class E are positive, whereas the skewnesses of Class A, Class B and Class C are negative. These statistics mean that most housing price growth rates of Class D and Class E are less than their means. By contrast, most housing growth rates of Class A, Class B and Class C are greater than their means. Considering this information, speculative investors will possibly invest in the mass markets rather than in the luxury markets. In this way, the mass markets would contain more bubbles. Such difference between different housing market segments in terms of the frequency of bubbles occurrence also supports the empirical finding that speculative demand is an important determinant for the Hong Kong housing bubbles.

5. Conclusions

The Hong Kong community has suffered from its skyrocketing housing price and Hong Kong Government attempts to increase its land supply to raise the housing supply, implements Special Stamp Duty and also decides to suspend the applications for Hong Kong investment immigration in order to offset the high housing price. However, by employing GSADF test, the results of detecting whether the housing market in Hong Kong contains bubbles show that seven bubbles existed in the Hong Kong housing market between 1993 and 2015, and the entire Hong Kong market contains a housing bubble, which can be attributed to the mass markets. Another important finding is the difference between different housing market segments in terms of the frequency of bubble occurrence. The mass residential markets experience more bubbles than the luxury ones.

Both static and dynamic probit models are constructed to address factors that lead to current housing bubble and such difference between the housing market segments. Empirical results show that from a dynamic viewpoint, it's the speculative demand from investors and the money supply that determine whether the housing market contains a bubble. Under the linked exchange rate system, the increase of money supply of Hong Kong Government, caused by the US loose monetary policies, serves as a positive shock and contributes to the initial increase of housing price. And then a positive feedback is noted between the speculative demand and the housing price increase, which would finally lead to the generation of bubbles. Considering the performances of both the mass markets and the luxury ones, speculative investors would prefer the former over the latter, which lead the mass markets to experience more bubbles than the luxury ones.

In conclusion, under the current linked exchange rate system, Hong Kong Government should be alert to the impacts of the US monetary policies on Hong Kong residential housing market. A more targeted and effective approach for Hong Kong Government is not to increase the land supply or suspend the investment immigration policy but to introspect the current linked exchange rate system and also to constrict the speculative activities of investors particularly in the mass markets. Neither increasing land supply to raise housing supply nor suspending the applications for immigration to Hong Kong could offset the current housing bubble. Besides, our empirical findings suggest that the current housing bubble in the Hong Kong market can be attributed to the mass markets and the luxury markets do not contain bubbles. In view of this, to constrict the speculative activities in the mass markets, policies such as imposing tax on capital gains should be made.

Notes

1. The critical value, for a given point in the time series data and for a given significance, is calculated as the 100 β_T percentile of the M (in this study, $M = 2000$) simulated values of the BSADF statistic.
2. 1.66 is the 90% of the asymptotic distribution of sub DF statistic.
3. According to Phillips et al. (2015), the GSADF test performs even well with smaller initial window of 12 observations.
4. $r_2 = r_1 + r_w$, $r_w > 0$ and it is the window length.
5. The mass markets in Hong Kong refer to markets of Class A, Class B and Class C.
6. The luxury markets in Hong Kong refer to markets of Class D and Class E.

7. The Hong Kong market of Class A refers to the market where houses are less than 40 sq.m.
8. The Hong Kong market of Class B refers to the market where houses are between 40 and 69.9 sq.m.
9. The Hong Kong market of Class C refers to the market where houses are between 70 and 99.9 sq.m.
10. The Hong Kong market of Class D refers to the market where houses are between 100 and 159.9 sq.m.
11. The Hong Kong market of Class E refers to the market where houses are more than 160 sq.m.
12. Here only detection results of GSADF tests and the cointegration test are compared, while those of variance bounds tests and West's two-step tests aren't incorporated. The reason is that the former two methods share different definitions about housing bubbles with the latter ones. GSADF tests and the cointegration test regard the explosive behaviour of housing prices as the signal of a bubble process, while variance bounds tests and West's two-step tests are based on the deviation of housing prices to the fundamental values.
13. The reason why we choose the first-order differenced expression lies where housing rents are I(1).
14. Typical examples are bubbles during the period of the Asian financial crisis and bubbles during the period of the subprime crisis.
15. Bubble periods identified for the entire market include 1996M11 to 1997M7, 2004M1 to 2004M5, 2004M9 to 2004M11, 2005M1 to 2005M5, 2009M3 to 2009M9, 2011M1 to 2011M7, and 2012M3 to 2015M11.
16. Bubble periods identified for Class A include 1997M1 to 1997M7, 2004M2 to 2004M5, 2005M2 to 2005M4, 2009M4 to 2009M10, 2010M1 to 2010M4, 2010M12 to 2011M7, and 2012M2 to 2015M11.
17. Bubble periods identified for Class B include 1997M1 to 1997M6, 2004M2 to 2004M5, 2004M9 to 2004M10, 2005M2 to 2005M5, 2009M3 to 2009M7, 2012M3 to 2012M6, and 2012M12 to 2015M11.
18. Bubble periods identified for Class C include 1996M12 to 1997M7, 1997M10, 2004M1 to 2004M5, 2004M9 to 2004M10, and 2005M2 to 2005M5.
19. Bubble periods identified for Class D include 1996M11 to 1997M7, 2003M10 to 2004M5, 2004M9 to 2005M7, and 2009M7 to 2009M9.
20. Bubble periods identified for Class E include 1996M12 to 1997M3, 1997M4 to 1997M5, 2003M12 to 2004M6, 2004M9 to 2005M6, and 2015M8 to 2015M9.
21. Speculative demand is measured by the myopic expectation of housing price changes. To be more specific, $SD_t = (HP\%)_{t-1}$, among which *SD* represents the speculative demand, and *HP*% represents housing price changes, and *t* represents time.
22. Many policies implemented by Hong Kong Government influence the housing market by affecting speculative demand, mortgage expansion and housing supply. Therefore, a classification of polices is conducted in this study to avoid the abuse of dummy variables.
23. According to Green (??), without actually specifying the type of heteroscedasticity, we can still make appropriate inferences based on the results using White estimators since the White estimators have robust variances.
24. In fact, the 24-month lagged dependent variable is still significant, but its McFadden R square decreases to .213, meaning that the goodness of fit is not satisfying. This phenomenon can be attributed to this property that most dependent variables are valued by zero and thus even the 24-month lagged dependent variable can predict the current one.
25. The US Federal Reserve has taken five rounds of quantitative easing, respectively, in 2008, 2010, 2012, 2013, and 2014.
26. In December 2015, the US Federal Reserve announced to raise the interest rate for the first time in recent nine years.

27. The Wald test shows that the standardised coefficient of speculative demand is significantly greater than the standardised coefficient of the change of money supply with *F*-statistics (1, 259) equaling 12.80617.

Disclosure statement

No potential conflict of interest was reported by the authors.

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