J Real Estate Finan Econ (2009) 38:254–274
DOI 10.1007/s11146-008-9155-x

Turnovers and Housing Price Dynamics: Evidence from Singapore Condominium Market

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Published online: 29 October 2008

Abstract Recent real estate literature has not only proposed a few theories to explain the puzzling macro feature of the positive correlation between price and transaction volume, but also attempted to identify the causal relationships between them. However, there is little empirical evidence to explicitly illustrate how housing price dynamics measured by both past price changes and price volatility at housing unit level affect housing turnovers. Using a unique housing transaction database from Singapore condominium market, this paper reveals an interesting housing turnover pattern in response to past housing price dynamics. The results illustrate that the rise and fall of a dwelling's price can significantly affect housing turnovers in the same direction. Higher volatility reduces housing turnovers. The effects are stronger in the domain of losses and are weakening as the cumulative housing equity rises, implying that a seller withholds the sale in the downswing of a real estate cycle in the hope that the market will rebound. The findings offer some additional micro empirical evidence to the interactions between housing price and transaction volume and imply upwardly biased repeat sales indexes.

Keywords Housing turnovers · Housing price dynamics · Price volatility · Value function

Introduction

A puzzling positive correlation between price and transaction volume has long been observed in asset markets. Real estate literature in this area falls into two streams. One stream of literature focuses on explaining the puzzle observed in housing markets, for example, Wheaton's search model (Wheaton 1990), Stein's down-payment constrained housing consumption model (Stein 1995), and nominal loss

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aversion approach proposed and tested by Genesove and Mayer (2001). Recently, some researchers attempt to find the common factors that drive the movements of both housing transactions and housing prices (Ortalo-Magné and Rady 2004, 2006; Jin and Zeng 2004; Iacoviello 2005).

The other stream of literature attempts to investigate how price and transaction volume interact. At the macro level, Leung et al. (2002) empirically identify a robust positive correlation between the housing price and the transaction volume in Hong Kong housing market, and show that transaction volume Granger causes property price movements. This is despite that Leung and Feng (2005) find weak evidence for Granger causality in Hong Kong commercial property market. The macro lead-lag relationship found in housing markets can be explained by the search theoretic model in Berkovec and Goodman (1996). They argue that a demand shock affects the number of buyers and their willingness to pay initially, but has no immediate impact on both buyers and sellers' price expectations. The mismatch between a buyer's offer price and a seller's reservation price lengthens the seller's time-on market. Sellers who have lower holding power may have to lower the reservation price in order to sell the unit. A demand shock is then transmitted into price changes. Hort (2000) further empirically tests the model against the Swedish data. Thus, the fact that transactions lead to price changes after a demand shock, is established, this is despite the finding by Andrew and Meen (2003) that transactions respond to shocks faster than prices but do not Granger cause price movements in the UK.

At the micro level, price related housing equity gains or losses can accelerate or delay a motivated seller's decision to sell. Case et al. (2005) point out that rising housing prices generate positive wealth for households, which is conveyed into positive housing and non-housing consumption. This may enhance household mobility as mobility is one of the vehicles for a household to adjust their housing consumption to the changes in circumstances (Rossi 1955). Falling housing prices may have a lock-in effect to constrain residential mobility (Chan 2001; Engelhardt 2003) or to incur a longer time-on-market due to down-payment constraint (Stein 1995; Genesove and Mayer 1997) or nominal loss aversion (Genesove and Mayer 2001). The micro theories suggest that increasing or decreasing housing prices reinforce the movements of transaction volume in the same direction. However, Wheaton and Lee (2008) conclude that higher volume generates higher subsequent prices, while higher prices generate lower subsequent volume, implying some inconsistency between their macro results and the existing micro theories. Hence, it is necessary to further quantitatively investigate how turnovers respond to the different levels of past housing price dynamics at the housing unit level.

The answers to the question are important. First, explicitly uncovering the relationship between turnovers and the price related housing equity changes at housing unit level provides a new channel to understand the macro interactions between price and transaction volume, which can improve our understanding on housing market fundamentals (Iacoviello 2005). Second, if a unit that has experienced higher housing price appreciations is traded more frequently, repeat sales indexes may be upwardly biased (Kiel 1994). The empirical relationship between turnovers and price changes may aid us to correct the bias. The constant-liquidity price index developed by Fisher et al. (2003) has shown the importance of incorporating 'ability to sell' into a price index. Third, policy makers are interested in the speculation related characteristics in a housing market. The relationship to be uncovered can lead us to have a better understanding on housing price bubbles or cycles.

The reminder of this paper is organized as follows: the next section summarizes the related literature. Data and variable selection are presented in the third section. Empirical results are reported in the fourth section, followed by a concluding section.

The Related Literature

Households are heterogeneous and their moving decisions can be triggered or held up by some unexpected events, but are not simply a response to 'triggers' or 'push–pull' factors. Their responses to housing market changes are different and complicated (Kan 1999; Hickman et al. 2007). Rising housing prices may constrain first time-buyers' housing affordability. But, for housing ladder climbers, rising housing prices may accelerate their decision to sell their unit because rapid housing price appreciations enable homeowners to accumulate the equity required to trade up to a more valuable house more quickly, which is likely to intrigue an earlier optimal timing of move (Nakagami and Pereira 1991). This is also consistent with the down-payment constrained consumption model (Stein 1995), the housing ladder or life cycle models in Ortalo-Magné and Rady (2004, 2006) and the housing wealth approach in Case et al. (2005). Lee and Ong (2005) use Singapore public owner occupied resale housing market transaction data to test how rising housing prices boost households' upward mobility (from public owner occupied housing market to private owner occupied housing market). Their results are consistent with the findings in Sing, Tsai and Chen (2006) using Singapore macro economic data. Rising housing prices may also significantly increase mortgage debt for some upgraders, which may constrain their mobility. This is true if housing prices in the upper end of a housing market rise faster than housing prices in the lower end of the housing market.

For down-graders who want to liquidize part of their housing equity, rising prices may also precipitate an earlier sale. Housing is both a consumption commodity and an investment asset. Housing price appreciations affect homeowners when they consider whether to change the housing portion of their investment portfolio by moving to another unit. Kiel (1994) shows that rapid housing price appreciations increase mobility because homeowners choose to use the equity gained to finance higher consumption of either housing or other goods, or choose to capture the gains in case housing prices fall in the future.

Thus, the investment aspect of buying a house plays an important role in household mobility decisions. The number of 'vertical' transactions along housing ladders accounts for the fluctuations of housing transactions in response to price changes. The 'horizontal' movers, who move within the same housing price ranges, do not fluctuate much over time (Ortalo-Magné and Rady 2000).

In the down-swing of a housing price cycle, falling housing prices can subsequently constrain household mobility. The down-payment constrained consumption model (Stein 1995; Lamont and Stein 1999) illustrates that falling housing prices constrain the potential movers. These movers may try 'fishing' by listing their current house at above market price in the hope of getting luck to raise enough money to pay a new down-payment. The conjecture is supported by the empirical evidence from a volume of international literature (Genesove and Mayer 1997; Benito 2006; Lee and Ong 2005). An alternative approach by Genesove and Mayer (2001) models the relationship between listed housing price, time-on-market and potential loss, proving that loss aversion affects sellers' behavior in a housing market. Losers are likely to stay in the market longer as they typically set an above market asking price. Thus, sellers' loss aversion drives the phenomenon of low transactions during the market downturn. The approach is then supported by a stream of housing literature (Engelhardt 2003; Wong 2008). The work of Ong et al. (2008) distinguishes loss aversion from disposition effect using Singapore housing transaction data including both foreclosure sales and non-foreclosure sales in Singapore condominium market. They prove the disposition effect among non-foreclosure sales and homeowners are reluctant to sell when they suffer losses.

Chan (2001) finds that there are severe constraints to mobility as a result of negative housing market shocks. The constraints arise from households not being able to repay their existing mortgage or raising sufficient funds for a new down-payment when the price substantially falls. There is also evidence of loss aversion contributing lower mobility rates. However, Engelhardt (2003) claims that household mobility is significantly influenced by nominal loss aversion and there is little evidence that low equity caused by falling price constrains mobility.

Krainer (2001) argues that financial constraints undoubtedly play an important role in a seller's decision to sell. However, without observing a seller's portfolio of debts and assets, we can not be sure if a longer time-on-market is due to down-payment constraint or due to loss aversion. The search theory, proposed by Wheaton (1990), further developed by Berkovec and Goodman (1996) and Krainer (2001) suggests that housing market trade friction contributes to the positive correlations between price and transaction volume. The trade friction is high in the down-swing of a housing price cycle because of the mismatch between a seller's reserve price and a buyer's offer price.

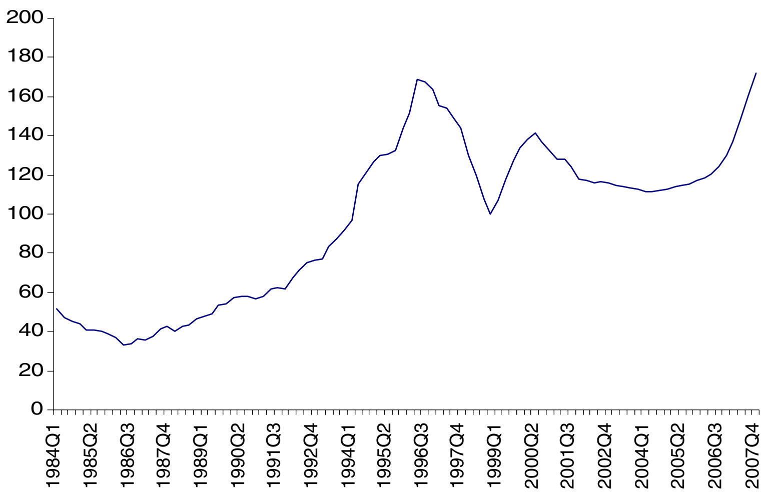
Some facts are established from the literature. A positive (or negative) demand shock initially increases (or decreases) the probability to sell which subsequently causes the rising (or falling) housing prices (Wheaton 1990; Berkovec and Goodman 1996; Krainer 2001). Falling housing prices decrease housing turnovers (Stein 1995; Genesove and Mayer 2001; Chan 2001), while rising housing prices increase housing turnovers (Case 1992; Case, Quigley and Shiller 2005; Ortalo-Magné and Rady 2004, 2006). Rising or falling transactions create boom or bust housing market sentiments which may further affect buyers and sellers' behaviors further. Hence, housing transactions and housing prices reinforced each other in the same direction.

The impacts of past price dynamics on turnovers depend on the magnitude of past housing price movements. For example, a moderate price fall may not necessarily constrain a seller's ability to pay a new down-payment, especially for an equity rich seller. Hence loss aversion is a better approach to explain why falling housing price delays a seller to sell the unit. When housing price falls dramatically, a seller is likely to face both loss aversion and down payment constraint as the proceeds from the sale of his home may be insufficient to repay the outstanding mortgage loan or to raise funds for a new down-payment. In both cases, search theory plays a role in interpreting how housing market trade friction links falling housing prices to low transactions.

The work of Chan (2001) addresses the impacts of past housing price dynamics on mobility, but the use of aggregate price indexes limits Chan's study to further quantitatively investigate how past returns affect mobility as well as to investigate the impacts of past price volatility on mobility. Han (2005) presents strong evidence to show that, when housing turnovers are modeled, using disaggregate housing price indexes to measure past housing equity changes can significantly improve the overall model fit. In her results, Pseudo R^2 has been significantly increased from 0.0493, when aggregate price indices are used, to 0.2452, when disaggregate price indices are used. The rest of the paper attempts to construct a set of building-based disaggregate housing price indexes, upon which we examine empirically how past returns and price volatility affect turnovers.

Data and Variable Selection

Our primary database is from Singapore Institute of Surveyors and Valuers (SISV) housing transaction database, including all condominium transactions from the 1st of July of 1992 to the 30th of June, 2003. This period covers two real estate cycles of different magnitudes (Fig. 1). After deleting uncompleted records, compulsory foreclosed transactions, as well as collective sales, we obtain 65,589 observations for this study, out of which, 49,724 (75.8%) observations are right censored. 15,865 (24.2%) observations have at least one subsequent sale during the period, out of which, 76% has only one subsequent sale. The database includes the details of



Source: Urban Redevelopment Authority

Fig. 1 Price indexes of Singapore condominiums address, dwelling related hedonic factors as well as contract dates. The date of temporary occupancy permit (TOP) is obtained from a variety of published books about Singapore condominiums. This date is used to calculate the age of a unit. The condominium project and neighborhood related spatial information is obtained from Singapore Street Directory and some published books. All data are geo-coded at the building level. It is noted that each condominium may have a few buildings and each building corresponds to one pair of *x*–*y* coordinates.

Housing transaction data allows us to explicitly construct past housing price dynamics for each individual housing unit. Hence, we can test the effects of past housing price dynamics on turnovers at the macro level. The disadvantage is that such dataset does not typically have household information, which may incur estimation biases, or heterogeneity. To minimize the problem, we adopt a probit model with heteroscedasticity (Greene 2000; Parikh and Sen 2006) and we have also constructed a few variables to proxy household social economic background.

The dependent variable ('*y*') in our study is a dummy variable with one indicating that a property is sold before the censored date, otherwise zero. The independent variables consist of three sets of variables reflecting past housing price dynamics, submarket effects and owner's information.

Past Housing Price Dynamics The literature review presented in the previous section has illustrated that the price related housing equity change (indicated by 'PRICE_EQUITY') may affect a homeowner's decision to sell a unit. In addition, housing price volatility (indicated by 'PRICE_VOLATILITY') during a holding period may also have an impact on the decision to sell.

To construct 'PRICE_EQUITY' and 'PRICE_VOLATILITY', the value of a housing unit in each quarter during a holding period needs to be estimated. Han (2005) has proved that using aggregate index numbers to estimate housing equity changes for a housing unit is not accurate, which can significantly reduce the overall model fit. Conventional hedonic or repeat sales models are not appropriate in predicting housing values across a space. Instead, a hedonic housing price Geo-statistical model (Dubin 2003) allows us to predict the value of a unit located in any site defined by a pair of *x*–*y* coordinates.

The present study adopts Singapore condominium transaction data, where each building has one pair of geo-codes. Hence, a hedonic price Geo-statistical model is used here to construct price indexes for each building in Singapore condominium market. Zhou (2007) uses Singapore condominium transaction data and illustrates that a hedonic price Geo-statistical model with annual transaction data outperforms the spatial-temporal autocorrelation model (Sun et al. 2005) as well as the conventional hedonic models in out-of-sample predictions.

The building_based price indexes constructed by a Geo-statistical model can better capture small area housing price dynamics. However, in a multi-story housing market, housing prices also vary with floor levels (along the vertical direction). The current Geo-statistical models cannot capture the price volatilities along the vertical direction. Hence, in this study, the units within one building share the same price volatilities indicated by the building_based housing price indexes. This is the disadvantage of the model. The empirical hedonic price geo-statistical models are not presented in this paper, but available at request.

'PRICE_EQUITY' is measured by the percentage change of the building_based index numbers between the time of sale or the censored date and the time of purchase[1]. The present study does not use the difference between the selling price and the purchasing price for those sold dwellings to measure 'PRICE_EQUITY', because a seller is assumed to have myopic price expectation. His self-estimation on the value of his property is typically based on the recent and past nearby transactions. The building_based price indexes constructed by a hedonic price Geo-statistical model reflect this feature.

To capture the pattern of turnovers in response to past returns, we further divide the price related housing equity changes ('PRICE_EQUITY') into 19 price increments or intervals. 'PRICE_EQUITY' is then transformed into a set of 19 dummy variables, each indicating a price range of 5% to 10% (see Table 4 of the Appendix)[2].

To capture the past housing price volatilities ('PRICE_VOLATILITY') of a unit, we design two variables in the present study. 'PRICE_MIN_MAX' is the difference between the largest building_based price index number and the smallest index number during a holding period. 'PRICE_σ^2' is the variance of the price index numbers during a holding period.

Submarket Effect Turnovers may vary across housing submarkets as the literature shows that housing prices vary across housing submarkets. Homebuyers' housing preferences are not only different, but also change over time. This may affect housing demand and supply at the submarket level, resulting in different turnover rates across submarkets (Tu 1997, 2003). Hedonic housing attributes, as well as the number of times that a unit was ever sold before the current sale (or censored date) which indicates the activeness of a submarket, are therefore selected to indicate the impacts of submarkets on turnovers.

Owner's Information Previous literature and economic theory on mobility emphasize the role of demographics or households' characteristics in the moving decision (Kan 2002, 2003; Rossi 1955). We generate three dummy variables to indicate a homeowner's personal wealth group. They are 'INC_LOW', 'INC_MIDDLE' and 'INC_HIGH'. A set of four dummy variables are created to indicate the time points along real estate cycles when an owner entered the market. They are 'ENTERr_96q2', 'ENTER_96q3_98q4', 'ENTER_99q1_02q2', and 'ENTER_02q2_03q2'. An owner's duration of ownership is indicated by 'HOLDING_PERIOD'. To further control the affordability, we adopt GDP, unemployment rate as well as mortgage rate as explanatory variables.

The initial or contemporaneous loan to value ratio ('LTV') as an indicator of housing equity level has been proven to be an important variable affecting an owner's decision to sell (Genesove and Mayer 1997; Stein 1995; Engelhardt 2003).

[1] $\text{PRICE\_EQUITY}(s_0, v, t) = \frac{PI_{t-1}(s_0) - PI_{t-v+1}(s_0)}{PI_{t-v+1}(s_0)}$, where, v is the holding period (quarter). PI is the index number at location s_0, t is the sale's or censored date.

[2] In our study, we have tried from a set of 10 dummy variables (each represents a larger range of price growth) to a set of 40 dummy variables (each represents a smaller range of price growth). The empirical results are consistent. And the results from a set of 19 variables are chosen to report.

High LTV ratio constrains an owner's mobility. In Singapore, a minimum 10% cash down payment was required before May 1996, and 20% was required between May 1996 and September 2002. It went back to a 10% down payment after that. A dummy variable to indicate policy changes is used as a proxy to measure the general initial equity condition of a buyer during the investigated period. The definition of variables discussed above is given in Table 4 of the Appendix.

The descriptive analyses of some key variables are presented in Tables 5 and 6 of the Appendix. On average, there were 24.19% of turnovers out of all observations during 11 years, covering two real estate cycles. Between any two consecutive sales, the holding period was 8.1 quarters with a standard deviation of 7.4 quarters, while for the censored cases, the average holding period was 18.81 quarters with a standard deviation of 8.6 quarters. A unit was sold eight times at the maximum with a mean of 0.32 and a standard deviation of 0.66 prior to the most recent sale. For a holding period, the average housing price related equity accumulation was 12% with a standard deviation of 0.30 for the uncensored cases. The maximum loss was −51%, while the maximum gain was four times as much as the purchasing price. For the censored cases, the average change in housing equity was −10.6% with a standard deviation of 0.20. The maximum loss was 51% and the maximum gain was 2.3 times as much as the purchasing price.

Across the 19 'PRICE_EQUITY' ranges (the definition of the ranges are given in Table 4 of the Appendix), the turnovers measured by the number of uncensored cases out of all observations in each range exhibited a clear upward trend when the housing price related equity accumulation varied from the maximum loss to the maximum gain (Table 1), demonstrating that a homeowner was unlikely to sell when he suffered nominal housing equity loss due to price changes, while an excessive price related housing equity change might induce a sale. For example, if an owner

Table 1 Turnovers vs 'PRICE_EQUITY' ranges

Price range	Turnovers
PRICE_EQUITY_1 (maximum loss)	0.039344
PRICE_EQUITY_2 (loss)	0.058036
PRICE_EQUITY_3 (loss)	0.058171
PRICE_EQUITY_4 (loss)	0.061853
PRICE_EQUITY_5 (loss)	0.078629
PRICE_EQUITY_6 (loss)	0.091638
PRICE_EQUITY_7 (loss)	0.102147
PRICE_EQUITY_8 (loss)	0.131253
PRICE_EQUITY_9 (loss)	0.145036
PRICE_EQUITY_10 (loss)	0.380797
PRICE_EQUITY_11 (gain)	0.343124
PRICE_EQUITY_12 (gain)	0.407066
PRICE_EQUITY_13 (gain)	0.398627
PRICE_EQUITY_14 (gain)	0.401692
PRICE_EQUITY_15 (gain)	0.486981
PRICE_EQUITY_16 (gain)	0.404364
PRICE_EQUITY_17 (gain)	0.467201
PRICE_EQUITY_18 (gain)	0.492262
PRICE_EQUITY_19 (maximum gain)	0.741372
Average	0.241900

The definition of variables is given in Table 4 of the Appendix had experienced more than 50% capital gains (the range is indicated by 'PRICE_EQUITY_19'), 74% of them might have sold the unit, compared with 46% sales for an owner who had experienced 40%-50% gains (the range is indicated by 'PRICE_EQUITY_18').

For the uncensored cases, the average 'PRICE_MAX_MIN' during a holding period was 44 percentage points with a standard deviation of 38.6, while for the censored cases, it was 59 percentage points with a standard deviation of 30.2. If price volatility is measured by variance ('PRICE_σ^2'), the same pattern is observed, implying that higher volatility may lead to a lower turnover rate. In the next section, we will report the magnitudes of the impacts.

Empirical Results

The objective is to calibrate a binary discrete choice model to obtain a robust relationship between housing turnovers and past housing price dynamics measured by price related equity change and housing price volatility during a holding period. The main problem is that our database does not include household information. Such misspecification may produce inconsistent estimates in probit model (Yatchew and Griliches 1984). To address the impact, we re-run the models using alternative sub-datasets, as well as systematically adding or deleting independent variables. The results demonstrate that the coefficients on housing equity variables and housing price volatility variables are not only robust in sign but also significant at 1% across all models. The coefficient estimates have slight variations, but the pattern of turnovers in response to past price dynamics are robust and consistent across all models, suggesting that our results are not being driven by model misspecifications.

Another problem is heteroscedasticity that is very common in micro economic data. Our empirical work has shown that a probit model with heteroscedasticity can significantly improve the overall model fit, compared with a probit model estimated under homoscedasticity assumption (see note 5 in Table 7 of the Appendix for details). After a series of heteroscedasticity tests, we find that housing price volatility ('PRICE_σ^2' or 'PRICE_MIN_MAX'), the timing of an owner entering the market ('PRICE_96q2') as well as owners' financial wealth measurement ('INC_MIDDLE', 'INC_HIGH') have significantly contributed to heteroscedasticity. And hence, probit model with heteroscedasticity is used. The macro economic variables ('GDP', 'RIR' and 'ERATE'), policy variable indicating initial loan to value change ('LTV') and holding period ('HOLDING_PERIOD') are insignificant across all models, indicating that they are either not the appropriate proxies or do not have an impact on turnovers. After the insignificant variables are omitted, we choose two empirical models to report in Table 2. The other four models are presented in Tables 7 and 8 of the Appendix.

All six empirical models (Table 2, Tables 7 and 8 of the appendix) demonstrate the acceptable levels of Goodness-of-Fit that are measured by likelihood ratio, Aldrich–Nelson–R^2, Cragg–Uhler 1−R^2, Cragg–Uhler 2–R^2, Estrella–R^2, Adjusted Estrella–R^2, McFadden's LRI–R^2, Veall–Zimmermann–R^2 and McKelvey–Zavoina–R^2. The six models vary in term of the measurement of past price dynamics.

Table 2 Empirical models-1 and 2

Variables	Model-1		Model-2	
	Coeff.	Std	Coeff.	Std
INTERCEPT	2.8549	0.1694	7.4809	0.3632
FLRAREA	0.0013	0.0002	0.0019	0.0004
LEVEL	−0.0264	0.0020	−0.0417	0.0032
FREEHOLD	−0.1848	0.0260	−0.1530	0.0395
AGE	−0.0413	0.0026	−0.0683	0.0042
GYM	0.1791	0.0275	0.1437	0.0000
JACUZZI	0.1409	0.0271	0.2536	0.0419
PLAYGROU	0.1464	0.0374	0.1489	0.0588
TENNIS	−0.5012	0.0369	−0.5900	0.0573
WADING	0.2679	0.0320	0.2723	0.0487
SECURITY	0.3773	0.0384	0.5850	0.0578
TOTALUNI	0.0004	0.0000	0.0004	0.0000
SCHOOL	−0.2168	0.0239	−0.2523	0.0375
CBD	0.0299	0.0032	0.0198	0.0050
PERVIOUS_SALETIMES	0.1034	0.0147	0.1464	0.0225
INC_MIDDLE	0.5864	0.0336	0.6962	0.0519
INC_HIGH	0.8797	0.0388	1.1450	0.0581
ENTER_96Q2	2.4643	0.0687	5.8793	0.1976
PRICE_σ^2	−0.0114	0.0004		
PRICE_MIN_MAX			−0.1402	0.0046
PRICE_EQUITY_1	−6.9077	0.9010	−12.8967	1.4381
PRICE_EQUITY_2	−8.0492	0.5391	−13.0352	0.8401
PRICE_EQUITY_3	−6.5933	0.2258	−11.2368	0.4366
PRICE_EQUITY_4	−5.9672	0.1863	−10.4093	0.3790
PRICE_EQUITY_5	−5.6180	0.1746	−9.5834	0.3519
PRICE_EQUITY_6	−5.3671	0.1683	−9.1195	0.3377
PRICE_EQUITY_7	−5.0678	0.1650	−8.7844	0.3315
PRICE_EQUITY_8	−4.8161	0.1628	−8.4816	0.3286
PRICE_EQUITY_9	−4.8408	0.1641	−8.6229	0.3346
PRICE_EQUITY_10	−4.2672	0.1613	−8.5039	0.3440
PRICE_EQUITY_11	−3.9345	0.1580	−7.5052	0.3248
PRICE_EQUITY_12	−3.5816	0.1573	−6.7737	0.3160
PRICE_EQUITY_13	−3.4048	0.1553	−6.4731	0.1553
PRICE_EQUITY_14	−3.4262	0.1557	−6.4383	0.3120
PRICE_EQUITY_15	−3.1913	0.1592	−5.6415	0.3194
PRICE_EQUITY_16	−3.3002	0.1596	−6.3323	0.3218
PRICE_EQUITY_17	−2.9462	0.1495	−5.5911	0.3030
PRICE_EQUITY_18	−2.6572	0.1505	−4.8658	0.3072
AIC	46,141		40,761	
Schwarz criterion	46,514		41,131	
Likelihood ratio (*R*)	26,514		26,345	
Upper bound of R (U)	72,573		67,024	
Aldrich–Nelson	0.2879		0.3024	
Cragg–Uhler 1	0.3325		0.3517	
Cragg–Uhler 2	0.4968		0.5265	
Estrella	0.3953		0.4234	
Adjusted Estrella	0.3941		0.4221	
McFadden's LRI	0.3653		0.3931	
Veall–Zimmermann	0.548		0.5766	
McKelvey–Zavoina	0.952		0.9596	

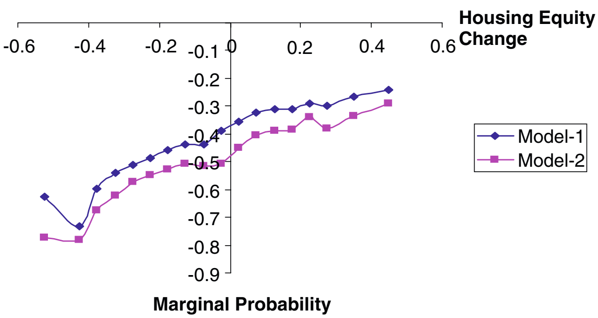
The dependent variable '*y*' is a dummy variable indicating if a unit is sold or censored. The definition of variables is given in Table 4 of the Appendix. All variables are significant at 1% expect that "PLAYGROU" is significant at 5%. The interpretation of statistical diagnoses can be found in (Greene 2000; Parikh and Sen 2006)

It is found that using a set of ‘PRICE_EQUITY’ dummy variables (Models-1 and 2 in Table 2) rather than using ‘PRICE_EQUITY’ as a continuous variable (Models-3 and 4 in Table 7 of the Appendix) can only slightly improve the overall model fit by 0.0005 (Veall–Zimmermann–R^2). However, using ‘PRICE_MIN_MAX’ (Model-2 in Table 2 and Model-4 in Table 7 of the Appendix) rather than using ‘PRICE_σ^2’ (Models-1 and 3 in Table 2 and Table 7 of the Appendix) can improve Veall–Zimmermann–R^2 by 0.03, implying that an owner’s self estimation on past price volatility is better represented by the difference between the maximum price and the minimum price during a holding period.

Across all six models, turnovers demonstrate a clear submarket pattern. Larger, younger and lower level leasehold condo units appear to have higher turnovers. The condo units associated with the facilities of Gym, Jacuzzi, Playground, Wadding pool and Security appear to have higher turnovers, while lower turnovers are observed in the condos with tennis court. Previously more frequently traded units are likely to have higher turnover rates. The results also show that the units in larger condo developments located near good schools but further away from the CBD have higher turnover rates. However, the impact of the CBD is not robust in our results (it appears to be insignificant in Model-6 in Table 8 of the Appendix). It has also been found that the units whose owners are wealthier homebuyers appear to have higher turnovers. This indirectly supports the down-payment constrained consumption model (Stein 1995). Our findings also show that the owners who entered the market between the second quarter of 1992 and the second quarter of 1996 have much higher turnovers. During the period, Singapore housing market experienced very fast price appreciation, and hence, many owners experienced a rapid housing equity accumulation through housing price appreciations, which might have led to the high turnovers.

The pattern of turnovers in response to price related housing equity changes (dummy variables for ‘PRICE_EQUITY is constructed against Models 1 and 2 in Table 2. It is illustrated by Fig. 2, where the *X*-axis stands for the price related housing equity change (e.g. 0.6 means the equity gain is 60%) during a holding period and the *Y*-axis stands for marginal probability to sell. The marginal probability to sell of a dummy variable indicates how predicted probability changes when the dummy variable switches from 0 to 1. In the present study, it represents the change of the predicted probabilities when the price related housing equity change drops from the highest range (the price related equity gain is above 50%) to one of the

Fig. 2 Marginal probability to sell vs price related housing equity change



Note: Models-1&2 are reported in Table 2.

lower ranges because the highest range is chosen as a base in Models 1 and 2 in Table 2. Hence, the marginal probabilities calculated against Models 1 and 2 are negative.

Figure 2 shows that marginal probability to sell is positively related to the price related housing equity change. Winners (with equity gains) have higher marginal probability to sell than losers (with equity loss). In the domain of moderate equity gains, a concave shape is observed. However, when an owner receives excessive equity gain (above 25% in the present study), the marginal probability to sell is accelerated, implying that higher equity gains may induce a sale as the realized capital gains can be used to finance consumption or re-invest into a larger property. These are broadly consistent with the conceptions of Case (1992), Case et al. (2005), and Ortalo-Magné and Rady (2004, 2006).

In the domain of losses, we observe a nearly linear curve in the range of initial losses (between −5% and 0), then it becomes concave when the losses fall into the range of −40% and −5%. As property value decreases to nearly half of the original value, the marginal probability to sell rises slightly, this is despite that our sample has excluded those foreclosed sales. Owners are typically reluctant to realize the losses as explained by the down-payment constrained consumption model or loss aversion approach (Stein 1995; Genesove and Mayer 2001). When losses are accumulated, the impacts are stronger. For example, a minor equity loss may result in an owner losing some housing equity but not affect his ability to pay a new down-payment. However, a major loss may make an owner not only unable to afford a new down-payment, but also unable to cover the mortgage after selling the property. Hence his marginal probability to sell is further decreased. When the losses go beyond 45% in this study, we observe that the marginal probability to sell slightly rises. One possible explanation is that some owners who have been holding up the sale may psychologically lose hope that the market may rebound in the short run. They sell the property to avoid further losses or to serve his housing consumption changes.

Higher housing price volatility reduces housing turnovers. The results in Model 1 of Table 2 and Model 3 of Table 7 in the Appendix show that marginal probability to sell decreases by −0.001 for each additional increment in volatility measured by σ^2, or by −0.007 (Model-2 of Table 2) or −0.008 (Model-4 of Table 7 in the Appendix) for each additional increment in volatility measured by the difference between the largest building_based index number and the smallest index number during a holding period.

Table 3 shows that in all ranges of the price related housing equity changes, higher volatility reduces marginal probability to sell. The effects are stronger in the domain of losses and are weakening as the cumulative housing equity rises, implying that sellers withhold their property when prices fall in the hope that the market will rebound eventually.

Main Conclusions and Remaining Concerns

The present paper represents one of the few attempts to empirically model housing turnovers in response to past housing price dynamics. One important contribution is

Table 3 Marginal probability of price volatility for the winners and losers

Capital losses (%)	Marginal probability to sell		Capital gains (%)	Marginal probability to sell	
	PRICE_σ^2 Model-5	PRICE_MIN_MAX Model-6		PRICE_σ^2 Model-5	PRICE_MIN_MAX Model-6
−0.6~−0.45	−0.0026	−0.0169	0~0.05	−0.0012	−0.0081
−0.45~−0.4	−0.0026	−0.0139	0.05~0.1	−0.0011	−0.0075
−0.4~−0.35	−0.0022	−0.0121	0.1~0.15	−0.0011	−0.0076
−0.35~−0.3	−0.0019	−0.0113	0.15~0.2	−0.0011	−0.0077
−0.3~−0.25	−0.0018	−0.0105	0.2~0.25	−0.0009	−0.0068
−0.25~−0.2	−0.0017	−0.0102	0.25~0.3	−0.0010	−0.0076
−0.2~−0.15	−0.0015	−0.0096	0.3~0.4	−0.0009	−0.0068
−0.15~−0.1	−0.0015	−0.0092	0.4~0.5	−0.0008	−0.0061
−0.1~−0.05	−0.0014	−0.0089	0.5~0.35	−0.0001	−0.0026
−0.05~0	−0.0013	−0.0090			

This table is derived from Models 5 and 6 of Table 8 in the Appendix. The first and the fourth columns indicate the ranges of the price related housing equity changes. Other columns give the marginal probability to sell for each additional increment in volatility. The definitions of 'PRICEσ^2' and 'PRICE_MIN_MAX' are given in Table 4 of the Appendix

that, with the help of hedonic price Geo-statistical model, we are able to explicitly reveal the links between housing turnovers and the price related housing equity changes (Fig. 2), verifying the observed macro feature of the positive correlation between housing price and trading volume. The findings are broadly consistent with the predictions of the existing theories (Wheaton 1990; Stein 1995; Genesove and Mayer 2001; Case 1992; Case et al. 2005; Ortalo-Magné and Rady 2004, 2006). Figure 2 also shows that, when a market has experienced excessive price inflations, the turnovers are accelerated, implying the possibility of real estate bubbles from positive feedbacks. The findings also support the conclusion in Kiel (1994) that repeat-sales indexes may produce biases in an upward direction. Finally, the impact of price volatility on turnovers indirectly provides evidence on a seller's withholding behavior in the down-swing of a housing price cycle.

One puzzling fact arises from the present paper. In the literature of loss aversion, almost all work on loss aversion adopts utility as a measurement of loss aversion (Schmidt and Zank 2005). If we use marginal probability to sell to measure loss aversion, the shape of Fig. 2 should have the features illustrated by the asymmetric S-shaped value function proposed in prospect theory (Kahneman and Tversky 1979; Tversky and Kahneman 1992). For example, the curve has diminishing sensitivity and it is concave in the domain of gains and convex in the domain of losses. However, Fig. 2 does not show these features. The puzzle may be due to two reasons. First, marginal probability to sell may not be an appropriate measurement of loss aversion. Second, the value function of housing as an asset may be different from the one in prospect theory, suggesting that housing as an asset may have fundamental differences from other financial assets.

The present paper has three limitations. First, the rationale of the paper stems solely from sellers' viewpoint, thus implicitly assuming buying side liquidity. The problem is that a seller wishes to sell but cannot find a buyer, as addressed in search theory (Wheaton 1990; Berkovec and Goodman 1996). The use of transaction data cannot fully reflect this selling constraint, hence, the marginal probabilities estimated in this paper may be upwardly biased. Using 'time-on-market' is perhaps a better way to model marginal probability to sell, but such data is not available for this study. Second, in this study, Singapore condominium transaction data is used, where, the objective of owners may lean more towards investment than consumption. Since investors may behave differently from owner occupiers, the results may be biased. Singapore public resale market is an owner occupier housing market which should be a good sample for this study, but the data is not available. Third, the empirical results in the paper are derived from a probit model under a time-constant probability distribution assumption. Kan (1999, 2000, 2002, 2003, 2007) all find strong evidence that time-varying probability distribution assumption is important. Besides, our empirical work also finds that a probit model with heterosedasticity can significantly improve the overall model fit. However, to embed the heterosedasticity and model specification into a probit model with time-varying probability distribution is difficult, at least for now. The limitations and the puzzle require further study in this area.

Acknowledgement We thank the support from the academic research fund (AcRF) in National University of Singapore. We thank Dr Wee Yong Yeo and an anonymous referee for their constrictive comments and suggestions.

Appendix

Table 4 Definition of variables

Variable	Definition (measurement)
Y	The dependent variable with one indicating the property is sold, zero indicating that it is censored
Independent variables	
Submarket information	
AREA	Built-in area measured in sq.m which indicates the size of an apartment
LEVEL	Floor level of an apartment
FREEHOLD	Dummy variable with 1 indicating the property is freehold, otherwise 0
AGE	Age of the property (number of quarters)
BBQ	Dummy variable with 1 indicating that the condo has a Barbecue area, otherwise 0
CARPARK	Dummy variable with 1 indicating that the condo has a Covered car park, otherwise 0
GYM	Dummy variable with 1 indicating the condo has a Gymnasium, otherwise 0
JACUZZI	Dummy variable with 1 indicating the condo has a Jacuzzi, otherwise 0
FITNESS	Dummy variable with 1 indicating the condo has a Fitness area/jogging track, otherwise 0
MINIMART	Dummy variable with 1 indicating the condo has a Minimart, other wise 0
MPH	Dummy variable with 1 indicating the condo has a Multi-purpose hall, other wise 0
PLAYGROU	Dummy variable with 1 indicating the condo has a Playground, otherwise 0
SAUNA	Dummy variable with 1 indicating the condo has a Sauna, otherwise 0
SQUASH	Dummy variable with 1 indicating the condo has a Squash court, otherwise 0
SWIMMING	Dummy variable with 1 indicating the condo has a Swimming pool, otherwise 0

Table 4 (continued)

Variable	Definition (measurement)
TENNIS	Dummy variable with 1 indicating the condo has a Tennis court, otherwise 0
WADING	Dummy variable with 1 indicating the condo has a Wadding pool, otherwise 0
SECURITY	Dummy variable with 1 indicating the condo has a 24_hours security system, otherwise 0
TOTAL_UNIT	Total number of units in a condo
MRT	Linear distance to the nearest MRT Station (km)
CBD	Linear distance to CBD (km)
SCHOOL	Dummy variable with 1 indicating that the unit is located within 1 km of one of the top 30 primary schools, otherwise 0
PREVIOUS_ SALE_TIMES	Excluding the current sale, the number of previous sales for a unit (times)
Price information[a]	
PRICE_EQUITY	Price related housing equity change, measured by the percentage change of the building _based price index[a] numbers at the time of sale/censored and at the time of purchase for a unit located in a building during a holding period. For example, PRICE_EQUITY is 0.2, meaning the unit has experienced 20% price inflation during the holding period
	A set of dummy variables coded as below:
PRICE_EQUITY_1	If −0.6<price_equity≤−0.45, price_equity_1=1, otherwise 0
PRICE_EQUITY_2	If −0.45<price_equity≤−0.4, price_equity_2=1, otherwise 0
PRICE_EQUITY_3	If −0.4<price_equity≤−0.35, price_equity_3=1, otherwise 0
PRICE_EQUITY_4,	If −0.35<price_equity≤−0.3, price_equity_4=1, otherwise 0
PRICE_EQUITY_5	If −0.3<price_equity≤−0.25, price_equity_5=1, otherwise 0
PRICE_EQUITY_6	If −0.25<price_equity≤−0.2,price_equity_6=1, otherwise 0
PRICE_EQUITY_7	If −0.2<price_equity≤−0.15,price_equity_7=1, otherwise 0
PRICE_EQUITY_8	If −0.15<price_equity≤−0.1,price_equity_8=1, otherwise 0
PRICE_EQUITY_9	If −0.1<price_equity≤−0.05, price_equity_9=1, otherwise 0
PRICE_EQUITY_10	If −0.05<price_equity≤0, price_equity_10=1, otherwise 0
PRICE_EQUITY_11	If 0<price_equity≤0.05, price_equity_11=1, otherwise 0
PRICE_EQUITY_12	If 0.05<price_equity≤0.1, price_equity_12=1, otherwise 0
PRICE_EQUITY_13	If 0.1<price_equity≤0.15, price_equity_13=1, otherwise 0
PRICE_EQUITY_14	If 0.15<price_equity≤0.2, price_equity_14=1, otherwise 0
PRICE_EQUITY_15	If 0.2<price_equity≤0.25, price_equity_15=1, otherwise 0
PRICE_EQUITY_16	If 0.25<price_equity≤0.3, price_equity_16=1, otherwise 0
PRICE_EQUITY_17	If 0.3<price_equity≤0.4, price_equity_17=1, otherwise 0
PRICE_EQUITY_18	If 0.4<price_equity≤0.5, price_equity_18=1, otherwise 0
PRICE_EQUITY_19	If 0.5<price_equity≤3.5, price_equity_19=1, otherwise 0
PRICE_MIN_MAX	The price volatility of a unit located in a building during a holding period, measured by the largest building_based index number minus the smallest index number during the period
PRICE_σ^2	The price volatility of a unit located in a building during a holding period, measured by the variance of the building_based index numbers across all quarters during the period
Owner's information	
LTV	Dummy variable indicating Initial Loan to Value Ratio. LTV=1 indicates Loan to Value ratio is 90%, LTV=0 indicates 80%
INC_LOW	Dummy variable with 1 indicating that an owner bought a unit which price falls into the lowest 25% of price range in the year of transaction, otherwise 0
INC_MIDDLE	Dummy variable with 1 indicating that an owner bought a unit which price falls into the price range between 25% and 75% in the year of transaction, otherwise 0
INC_HIGH	Dummy variable with 1 indicating that an owner bought a unit which price falls into the price range above 75% in the year of transaction, otherwise 0
ENTER_96Q2	Dummy variable with 1 indicating that a homebuyer bought a unit before the 2nd quarter of 1996, otherwise 0
ENTER_96Q3_98Q4	Dummy variable with 1 indicating that a homebuyer bought a unit between the 3rd quarter of 1996 and the 4th quarter of 2002, otherwise 0.

Table 4 (continued)

Variable	Definition (measurement)
ENTER_99Q1_02Q2	Dummy variable with 1 indicating that a homebuyer bought a unit between the 1st quarter of 2002 and the 2nd quarter of 2002, otherwise 0
ENTER_02Q3_03Q2	Dummy variable with 1 indicting a homebuyer bought a unit between the 3rd quarter of 2002 and the 4th quarter of 2003, otherwise 0
HOLDING_PERIOD	The duration of a holding period (quarter)
GDP	GDP growth rate (quarter %)
RIR	Real mortgage rate (%)
ERATE	Employment rate (%)

[a] The price information of a unit is estimated against a set of building_based price indexes, which are constructed against a set of empirical hedonic price Geo-statistical models. The empirical models are not presented in this paper, but available at request

Table 5 Descriptive statistics-1

	Variable	*N*	Min	Max	Mean	Std
All data	AREA (sqm)	65,589	30	967	137.6199	59.1459
	LEVEL	65,589	1	38	7.3382	5.7762
	AGE (quarter)	65,589	0	30	3.5565	5.2946
	CBD (km)	65,589	0.73	22.12	8.7435	4.1330
	MRT (km)	65,589	0.08	12.16	1.4050	0.8546
	TOTAL_UNIT	65,589	8	1,232	384.7575	309.0582
	PREVIOUS_SALES_TIMES	65,589	0	8	0.3222	0.6650
	PRICE_EQUITY	65,589	−0.5200	3.0960	−0.0510	0.2488
	PRICE_MIN_MAX	60,786	0	286.6112	55.0548	32.9864
	PRICE_σ^2	65,589	0	8,414.32	353.7341	403.4261
	HOLDING _PERIOD	65,589	0	33.4667	16.2219	9.4918
Censored	AREA (sqm)	49,724	30	967	137.0390	56.5494
	LEVEL	49,724	1	38	7.5781	5.9092
	AGE (quarter)	49,724	0	30	3.7750	5.4980
	CBD (km)	49,724	0.73	22.12	8.6863	4.1352
	MRT (km)	49,724	0.08	12.16	1.4084	0.8580
	TOTAL_UNIT	49,724	8	1,232	376.3173	299.2213
	PREVIOUS_SALES_TIMES	49,724	0	8	0.3191	0.6551
	PRICE_EQUIT	49,724	−0.5200	1.2479	−0.10631	0.1999
	PRICE_MIN_MAX	46,185	0	236.2039	58.5427	30.1652
	PRICE_σ^2	49,724	0	4,030.98	355.1817	354.3193
	HOLDING_PERIOD	49,724	0.025	33.46667	18.81249	8.5830
Un-censored	AREA (sqm)	15,865	42	967	139.4405	66.6004
	LEVEL	15,865	1	37	6.5867	5.2680
	AGE (quarter)	15,865	0	24	2.8716	4.5312
	CBD (km)	15,865	0.73	22.12	8.9224	4.1212
	MRT (km)	15,865	0.08	12.16	1.3942	0.8440
	TOTAL_UNIT	15,865	8	1,232	411.2107	336.6815
	PREVIOUS_SALES_TIMES	15,865	0	7	0.3321	0.6948
	PRICE_EQUITY	15,865	−0.5147	3.0960	0.1224	0.3019
	PRICE_MIN_MAX	14,601	0	286.6112	44.0221	38.6206
	PRICE_σ^2	15,865	0	8,414.32	349.1973	528.5505
	HOLDING_PERIOD	15,865	0	33.06667	8.1027	7.3908

Table 6 Descriptive analysis-2

Dummy variable	All (%)	Uncensored (%)	Censored (%)
Y	24.1	n/a	n/a
BBQ	68.01	68.47	67.87
CARPARK	85.22	86.35	84.86
GYM	61.91	64.02	61.23
JACUZZI	20.5	23.2	19.64
FITNESS	43.69	47.39	42.51
MINIMART	9.76	9.81	9.74
MPH	43.9	45.8	43.29
PLAYGROU	82.17	84.96	81.28
SAUNA	56.61	59.21	55.78
SQUASH	64.5	67.01	63.71
SWIMMING	94.99	95.93	94.68
TENNIS	77.64	79.55	77.03
WADING	77.01	78.7	76.47
SECURITY	92.54	94.23	92
SCHOOL	42.05	39.67	42.8
LTV	55.51	73.87	49.65
INC_LOW	25.53	26.27	25.3
INC_MIDDLE	48.36	47.72	48.56
INC_HIGH	25.66	25.84	25.6
ENTER_96Q2	50.08	70.73	43.49
ENTER_96Q3_98Q4	21.85	21.44	21.98
ENTER_99Q1_02Q2	23.14	7.51	28.12
ENTER_02Q3_03Q2	4.93	0.32	6.4
Total			

Table 7 Empirical models 3 and 4

Variables	Model-3		Model-4	
	Coeff.	Std	Coeff.	Std
INTERCEPT	−1.3186	0.0718	−0.6556	0.1044
FLRAREA	0.0012	0.0002	0.0016	0.0003
LEVEL	−0.0275	0.0020	−0.0409	0.0029
FREEHOLD	−0.1892	0.0262	−0.1785	0.0359
AGE	−0.0404	0.0026	−0.0595	0.0038
GYM	0.1993	0.0277	0.2087	0.0389
JACUZZI	0.1467	0.0272	0.2702	0.0384
PLAYGROU	0.1523	0.0372	0.1118	0.0524
TENNIS	−0.5254	0.0370	−0.6028	0.0520
WADING	0.2794	0.0318	0.2855	0.0437
SECURITY	0.3531	0.0381	0.4924	0.0535
TOTALUNI	0.0004	0.0000	0.0003	0.0001
SCHOOL	−0.2185	0.0240	−0.2300	0.0338
CBD	0.0279	0.0032	0.0132	0.0044
PERVIOUS_SALETIMES	0.1028	0.0147	0.1700	0.0210
INC_MIDDLE	0.5969	0.0331	0.6271	0.0464
INC_HIGH	0.8638	0.0375	0.9441	0.0518
ENTER_96Q2	2.3104	0.0622	4.7784	0.1575
PRICE_EQUITY	5.2745	0.1191	6.7772	0.1793
PRICE_σ^2	−0.0111	0.0003		
PRICE_MIN_MAX			−0.1045	0.0032
AIC	46,142		40,881	
Schwarz criterion	46,360		41,097	

Table 7 (continued)

Variables	Model-3		Model-4	
	Coeff.	Std	Coeff.	Std
Likelihood ratio(R)	26,479		26,192	
Upper bound of $R(U)$	72,573		67,024	
Aldrich–Nelson–R^2	0.2876		0.3011	
Cragg–Uhler–R^2	0.3322		0.3501	
Cragg–Uhler 2–R^2	0.4963		0.5240	
Estrella	0.3948		0.4210	
Adjusted Estrella–R^2	0.3941		0.4202	
McFadden's LRI–R^2	0.3649		0.3908	
Veall–Zimmermann–R^2	0.5475		0.5742	
McKelvey–Zavoina–R^2	0.9485		0.9350	

The dependent variable 'y' is a dummy variable indicating if a unit is sold or censored. The definition of variables is given in Table 4 of the Appendix. All variables are significant at 1% expect that "PLAYGROU" is significant at 5%. The interpretation of statistical diagnoses can be found in (Greene 2000; Parikh and Sen 2006). To illustrate the importance of heteroscedasticity, we re-estimate Model-3 under homoscedasticity assumption. We have found that the overall model fit is significantly reduced, compared with Model-3 presented in Table 7 above. For example, likelihood ratio (R) drops nearly 40%, while Aldrich–Nelson–R^2 drops about 29%

Table 8 Empirical models 5 & 6

Variables	Model-5		Model-6		
	Coeff.	Std	Variables	Coeff.	Std
INTERCEPT	−1.3089	0.0744	INTERCEPT	−0.5559	0.1116
FLRAREA	0.0015	0.0002	FLRAREA	0.0020	0.0004
LEVEL	−0.0273	0.0022	LEVEL	−0.0401	0.0031
FREEHOLD	−0.1800	0.0271	FREEHOLD	−0.1233	0.0384
AGE	−0.0504	0.0027	AGE	−0.0706	0.0040
GYM	0.1199	0.0288	GYM	0.1444	0.0418
JACUZZI	0.0978	0.0283	JACUZZI	0.2201	0.0411
PLAYGROU	0.155	0.0384	PLAYGROU	0.1187	0.0564
TENNIS	−0.5016	0.0379	TENNIS	−0.5867	0.0552
WADING	0.3139	0.0331	WADING	0.2854	0.0469
SECURITY	0.4083	0.0396	SECURITY	0.5649	0.0569
TOTALUNI	0.0004	0.0001	TOTALUNI	0.0004	0.0001
SCHOOL	−0.2118	0.0248	SCHOOL	−0.2447	0.0363
CBD	0.0194	0.0034	CBD	0.0045	0.0048#
PERVIOUS_SALETIMES	0.0776	0.0152	Pervious_SaleTimes	0.1444	0.0221
INC_MIDDLE	0.4768	0.0347	inc_middle	0.5429	0.0492
INC_HIGH	0.7439	0.0388	inc_high	0.8693	0.0552
ENTER_96Q2	3.2776	0.0773	Enter_96q2	6.2384	0.1718
PRICE_σ^2* PRICE_EQUITY_1	−0.03	0.0039	PRICE_MIN_MAX* Price_Equity_1	−0.2679	0.0275
PRICE_σ^2* PRICE_EQUITY>_2	−0.0308	0.0021	PRICE_MIN_MAX* Price_Equity_2	−0.2192	0.0127
PRICE_σ^2* PRICE_EQUITY_3	−0.0252	0.0009	PRICE_MIN_MAX* Price_Equity_3	−0.192	0.0061
PRICE_σ^2* PRICE_EQUITY_4	−0.0222	0.0006	PRICE_MIN_MAX* Price_Equity_4	−0.1795	0.0051
PRICE_σ^2* PRICE_EQUITY_5	−0.0209	0.0006	PRICE_MIN_MAX* Price_Equity_5	−0.1658	0.0046

Table 8 (continued)

Variables	Model-5		Variables	Model-6	
	Coeff.	Std		Coeff.	Std
PRICE_ σ^2* PRICE_EQUITY_6	−0.0199	0.0005	PRICE_MIN_MAX* Price_Equity_6	−0.1609	0.0045
PRICE_ σ^2* PRICE_EQUITY_7	−0.0179	0.0005	PRICE_MIN_MAX* Price_Equity_7	−0.1524	0.0043
PRICE_ σ^2* PRICE_EQUITY_8	−0.0169	0.0005	PRICE_MIN_MAX* Price_Equity_8	−0.1458	0.0042
PRICE_ σ^2* PRICE_EQUITY_9	−0.0165	0.0005	PRICE_MIN_MAX* Price_Equity_9	−0.1405	0.0040
PRICE_ σ^2* PRICE_EQUITY_10	−0.0153	0.0005	PRICE_MIN_MAX* Price_Equity_10	−0.1419	0.0042
PRICE_ σ^2* PRICE_EQUITY_11	−0.0140	0.0005	PRICE_MIN_MAX* Price_Equity_11	−0.1285	0.0039
PRICE_ σ^2* PRICE_EQUITY_12	−0.0128	0.0005	PRICE_MIN_MAX* Price_Equity_12	−0.1187	0.0038
PRICE_ σ^2* PRICE_EQUITY_13	−0.0122	0.0005	PRICE_MIN_MAX* Price_Equity_13	−0.1197	0.0038
PRICE_ σ^2 PRICE_EQUITY_14	−0.0126	0.0005	PRICE_MIN_MAX* Price_Equity_14	−0.1219	0.0040
PRICE_ σ^2* PRICE_EQUITY_15	−0.0111	0.0005	PRICE_MIN_MAX* Price_Equity_15	−0.1069	0.0040
PRICE_ σ^2* PRICE_EQUITY_16	−0.0119	0.0005	PRICE_MIN_MAX* Price_Equity_16	−0.1199	0.0041
PRICE_ σ^2* PRICE_EQUITY_17	−0.0102	0.0004	PRICE_MIN_MAX* Price_Equity_17	−0.1077	0.0037
PRICE_ σ^2* PRICE_EQUITY_18	−0.0087	0.0004	PRICE_MIN_MAX* Price_Equity_18	−0.0963	0.0037
PRICE_ σ^2* PRICE_EQUITY_19	−0.0006	0.0004#	PRICE_MIN_MAX* Price_Equity_19	−0.0414	0.0030
AIC	47370		AIC	41597	41597
Schwarz Criterion	47743		Schwarz Criterion	41967	41967
Likelihood ratio (*R*)	25285		Likelihood ratio (*R*)	25509	25509
Upper bound of *R* (*U*)	72573		Upper bound of *R* (*U*)	67024	67024
Aldrich–Nelson–R^2	0.2782		Aldrich–Nelson–R^2	0.2956	0.2956
Cragg–Uhler 1–R^2	0.3199		Cragg–Uhler 1–R^2	0.3427	0.3427
Cragg–Uhler 2–R^2	0.4780		Cragg–Uhler 2–R^2	0.5131	0.5131
Estrella–R^2	0.3775		Estrella–R^2	0.4103	0.4103
Adjusted Estrella–R^2	0.3763		Adjusted Estrella–R^2	0.4090	0.4090
McFadden's LRI–R^2	0.3484		McFadden's LRI–R^2	0.3806	0.3806
Veall–Zimmermann–R^2	0.5297		Veall–Zimmermann–R^2	0.5637	0.5637
McKelvey–Zavoina–R^2	0.9758		McKelvey–Zavoina–R^2	0.9614	0.9614

The dependent variable '*y*' is a dummy variable indicating if a unit is sold or censored. The definition of variables is given in Table 4 of the Appendix. All variables are significant at 1% expect that the variables indicated by number symbol are significant at 10%. The interpretation of statistical diagnoses can be found in (Greene 2000; Parikh and Sen 2006)

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