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Expected Return of Housing and Mortgage Termination

Nai Jia Lee
National University of Singapore, Department of Real Estate, School of Design and Environment, National University of Singapore, 4 Architecture Drive, Singapore 117566, or rstlnj@nus.edu.sg

The prepayment risk of adjustable rate mortgages, unlike that of fixed rate mortgages, greatly depends on the decision of mortgagors to move. Given that housing also serves as an investment asset for the owner, it is hypothesised that the expected capital returns of housing are likely to affect his decision to move and hence, prepay. This paper aims to test the capital gains hypothesis using Singapore's housing market as a case study. In addition, this paper also explores how the expected returns from alternative types of housing affect the decision of households to move/prepay. The expected returns of housing are computed in accordance with the definitions of the Rational Expectation Hypothesis, Adaptive Expectation Hypothesis, and Exogenous Expectation Hypothesis, which are well established in macroeconomic literature and the explanation of cycles. The results showed that the expected returns of public housing formed under the assumptions of rational and adaptive expectation hypothesis are significant. The rational expected return for private housing, however, does not have a significant relationship with the decision of mortgagors to move/prepay, although the adapted expected return for private housing is not significantly related to the households' length of stay.

Key words
Expected Returns, Prepayment

Introduction

The management and understanding of the prepayment risk of mortgages are important to investors, secondary mortgage institutions, and insurance

agencies in their dealings in the secondary mortgage market. Bruggerman and Fisher (2002) showed that prepayment risk can seriously affect the periodic payoffs for Mortgage Pass Throughs and Collaterialised Mortgages Obligations instruments. When borrowers prepay, the financial institutions and individuals investing in such instruments are likely to suffer a cut in their profits, especially if the reinvestment rate is low. In addition, prepayment risk is an expensive cost to originators who issue Mortgage Backed Bonds and insurance agencies who guarantee the payments to investors.

What then causes prepayment? On one hand, many studies (Dunn and McConnel, 1981; Buser and Hendershott, 1984; Brennan and Schwartz, 1985; Kau, Keenan, Muller, and Epperson, 1995; Harding, 1994; Quigley and Van Order, 1995) have established that prepayment for fixed rate mortgages (FRM) is predominantly attributed to changes in market mortgage rates with respect to the contract rates. On the other hand, prepayment for adjustable rate mortgages (ARM) is more complex to model. Given that the mortgage rate is adjustable, the value of the call option is largely diminished. In fact, Chow, Hwang, and Liu (2000), using the contingent claims methodology, found that the value of the prepayment option for Hong Kong ARMs is nearly zero. Nevertheless, prepayment risk for ARM still exists and is directly related to the decision of mortgagors to move. When mortgagors move, they have to repay their outstanding loans so that they can transfer the property rights to the sellers. Zorn and Lea (1989) and He and Liu (1998) further showed empirical evidence of the prepayment of mortgage loans.

Since housing is a consumer as well as an investment good (Wheaton and Dispasquale, 1996), we further hypothesise that the expected returns of mortgagors' dwellings and those of other forms of housing will influence the decision of households to move and prepay. Hence, this paper aims to test the capital gain hypothesis using Singapore's housing market as a case study. The expected returns of housing are computed in accordance with the definitions of the Rational Expectation Hypothesis, Adaptive Expectation Hypothesis, and Exogenous Expectation Hypothesis, which are well established in economic literature and the explanation of cycles.

The choice of Singapore's housing market was not arbitrary. The clear segmentation of the housing market in Singapore – public versus private housing markets – offers an ideal opportunity for us to examine how the returns from one sector affect the decision of households to move and hence prepay. In addition, the Singaporean Government has been trying to develop a secondary mortgage market since 1998, and the prepayment risk of mortgages has not yet been well researched. An understanding of how expected market returns from housing affect prepayment risk will be useful to market participants in the secondary mortgage market.

The paper will be structured as follows: in the subsequent section, we will review past studies on the expectation hypothesis in real estate literature. In Section 3, we will further describe the methodology used to determine the factors affecting prepayment decisions. The results are analysed in Section 4 and the study concludes with the implication of the results in Section 5.

Literature Review

Many studies on mortgage prepayment have discussed and analysed the modelling of the prepayment option and the valuation of the option under a fixed rate mortgage framework. Yet few studies have touched on prepayment behaviour in a market of adjustable rate mortgages only. Nevertheless, Zorn and Lea (1989) and He and Liu (1998) reviewed the prepayment patterns of adjustable rate mortgages. Zorn and Lea (1989) employed logit and tobit tests to study the mortgage repayment behaviour in Canada, and compared the results with those conducted in the U.S.. Their results showed that housing prices are negatively related to the probability of prepayment. They explained that such a situation occurs because the increased housing price in an illiquid market would prevent households from moving. Alternatively, if the housing market is liquid, an increase in price would enhance the rate of prepayment.

Like the Canadian mortgage market, most of the mortgages originated in Hong Kong are adjustable rate mortgages. He and Liu (1998) tried to discover the prepayment patterns in the Hong Kong mortgage market using the proportional hazard model. Their variables included the interest rate mark up, the competition among banks, accessibility of borrowers to capital, and changes in housing prices. They hypothesised that a slight fall in housing prices would signal a possible downturn of the housing market, and trigger prepayments, assuming that most owners are speculators. Their empirical results further supported their hypothesis. This result offers an interesting insight: borrowers' prepayment behaviour greatly depends on their expectations on housing prices.

Expectations are fundamental in economics (Minford and Peel, 2002), since every economic decision is about the future, given the existing situation. The mortgagor's decision to move is analogous to an economic decision because he or she has to circumspect all future benefits or decisions that depend on his or her decision to move. The concept of expectations is well established in macroeconomics, and is instrumental in explaining the efficiency of markets and the impact of exogenous changes introduced into the market.

The adaptive expectations or backward looking expectation model assumes market participants form expectations based on some pattern or past

behaviour in the market. The adaptive expectations model is widely employed in modelling agricultural markets (see Nerlove, 1958) because models embodying this assumption are readily able to generate stable cyclical fluctuations. Although such adaptive expectation models are frequently criticised as being ad hoc, there is evidence from consumer surveys that consumers frequently operate in this manner (Case and Shiller, 1988). A characteristic of the adaptive expectations model is that the price cycle will be unable to converge on its steady state, and the cycle will exist by itself without any cyclical movements in the market exogenous variables (Dispaquale and Wheaton, 1996).

The rational expectations hypothesis was first put forth by Muth (1961). The rational expectations hypothesis assumes that people's subjective probability distributions about future outcomes are the same as actual probability distributions, conditional on the information available to them. In other words, consumers are perfectly informed about the operation of the market. The tests of the rational expectation hypothesis are made possible through the form of testing the 'efficient market hypothesis' pioneered by Fama (1970, 1976). Essentially, under rational expectations, prices follow a random work. They are efficient and unpredictable because lagged values of no variable have an influence on price movements. In other words, a market shock does not set off a cyclical pattern; there is only a single price overshoot (Dispaquale and Wheaton, 1996).

Besides the above two expectations hypotheses, we also constructed price expectations based on the exogenous price expectation hypothesis. Under the exogenous expectations hypothesis, the expectations are formed independently of local market behaviour. Such attitudes might exist if households believed that future prices rise with general economic inflation or some long-run growth rate that is largely unaffected by short run movements in price. The exogenous expectations model relies on the assumption that market participants' beliefs are constant over time and not affected by recent price behaviours in the market (Dispaquale and Wheaton, 1996). Although the assumptions are restrictive, the exogenous expectations model offers a useful intellectual exercise.

The concept of expectations was tested indirectly in the real estate literature through examinations of the efficiency of housing markets. Life Cycle models under rational expectations imply that housing prices follow a random walk and exhibit seemingly cyclical behaviour only if the exogenous variables that affect the market have random movements (Meen, 2003). All evidence, however, suggests that housing markets are neither efficient nor can be characterised as a random walk (Englund and Ioannides, 1997; Gatzlaff and Tirtiroglu, 1995; Cho, 1996; Dispaquale and Wheaton, 1994; Mankiw and Weil, 1989). The factors that account for the market's

inefficiency appear to be the presence of transaction costs and credit market constraints (Quigley, 2003).

Since housing prices are reflective of the actions of would-be movers, the above implies that the expected returns from public and private housing influence the decisions of would-be movers. In addition, the inefficient market also implies that households expect the market to rise if past prices are rising. This appears to be true, since Case and Shiller (1988) found respondents' attitudes about likely future price appreciation to be highly correlated with recent price behaviour. This paper attempts to extend the literature by studying whether the expected returns of housing influence the decision of household to move and prepay.

Methodology and Data

Data

The households whose decision to move and prepay are examined in this study lived in Housing Development Board (HDB) resale flats. The HDB flats are apartments constructed by the government and can be purchased directly from the HDB or in the secondary market. In Singapore, the housing market is split into the private and public sectors. Although the quality of the HDB flats are good compared to that of public housing in other countries, most Singaporeans prefer to live in private apartments because of the lifestyle and prestige that are associated with living in private apartments. In fact, owning a private apartment is so desirable that it has become a national phenomenon (Koh and Ooi, 1996). There are two main reasons for modelling the mobility and prepayment decisions of households living in HDB flats instead of private households. First, we can test the relationship between the returns on private housing with respect to the mobility decision of households living in HDB resale flats.[1] Second, from the operational point of view, the HDB has the largest pool of mortgages compared to any other single private institution. In addition, the HDB, being a Government Statutory Board, has the financial strength and expertise to ensure that the securitisation exercise is successful.

The data for this study was provided by an HDB Branch Office of Singapore. This chosen HDB estate is one of the earliest HDB estates to be built. The majority of flats in the chosen estate are more than ten years old, and there is a lot of resale activity going on in this area. From a total stock of 37,000 units in the estate, a sample of 594 resale mortgages spanning a period from

1 It is acknowledged that it will be useful to test the mobility decisions of households living in private housing against the expected returns of HDB resale flats. The unavailability of information for these households prevents further study along this angle.

1982 to 2000 was observed. For each loan, we were further provided the borrower's characteristics at the time of the purchase of the flat, the characteristics of property, and the characteristics of loans at the point of purchase and sale of the flat. Using the information obtained from mortgages, we modelled the households' occupation period against four categories of independent variable: the borrower, property, loan, and macroeconomic explanatory variables.

It is noted that the prepayment of the mortgages can occur in two instances: at the time of refinance or sale. In the case of the latter, the owner can only sell the resale flat after two and a half years from the date of purchase. Since most prepayment decisions are based upon the resale of flats, we modelled the motivation to prepay against the same variables as well.

Methodology

Past studies have utilised survival duration models to analyse the decision of households to move or prepay. Green and Shoven (1986), Quigley (1987) and Schwartz, and Torus (1989) used the duration analysis to model the suboptimal behaviour of borrowers. In the local context, Ong (2000) and Ong and Thang and Maxam (2002) also used hazard rates to model prepayment rates. On the other hand, Ioannides (1987) and Pickles and Davis (1991) used the duration models to understand the tenure choice of homebuyers. Following the past literature, this study will apply the same methodology to determine the factors affecting the decision of households to prepay and move.

The hazard rate used in this study is the prepayment rate, or the mobility rate of households living in HDB flats. In other words, the hazard rate is the instantaneous rate of a prepayment/move, conditional upon the property having survived prepayments/moves up until that time. The duration of time between loan origination or the purchase of property and prepayment for i^{th} property is denoted as T_i depending on the hazard rate.

The probability the distribution of duration can be specified by the distribution function:

$$F(t) = \Pr(T < t) \tag{1}$$

which specifies the probability that the random variable T is less than some value *t*. The corresponding density function is:

$$f(t) = \frac{dF(t)}{dt} \tag{2}$$

In studying duration data, it is also useful to study the survivor function where:

$$S(t) = 1 - F(t) \\ = \Pr(T \geq t), \tag{3}$$

which is the probability that the random variable T will equal or exceed the value t. The hazard function is then:

$$\lambda(t) = \frac{f(t)}{S(t)} \tag{4}$$

In this study, we employ two approaches to study the effect of postulated covariates on the prepayment or mobility rate: the non-parametric and the parametric duration models.

The Non-Parametric Model

The sample survivor function for a sample of n observations without censoring is:

S(t)=n-1 (No. of sample points ≥ t) (5)

where the empirical cumulative distribution is turned around. Censoring occurs when the observation could not be made, as the starting point or the ending point is out of the study period. The life table approach of Cutler and Ederer (1958) will be used for non-parametric analysis, allowing for censored observations (Kiefer, 1988). Observations that are censored are borrowers who have not yet prepaid or moved as of late June 2000.

Suppose the completed durations in the sample are ordered from the smallest to the largest, t1 < t2 < t3 < …< tk. The number of completed durations of K is less than n because of censoring and ties. (Ties occur when two or more observations have the same duration.) Let hj be the total number of prepayments at duration tj, for j=1 ,…, K. In the absence of ties, the hj are equal to one. Let mj be the number of observations with durations greater than tj, the longest complete duration. The hazard rate at duration tj for j=1 to K, is the probability of a prepayment at duration tj, conditional upon the property having survived prepayment up until tj. Thus, the hazard rate will be:

$$\lambda(t_j) = \frac{h_j}{n_j} \tag{6}$$

where:

$$n_j = \sum_{i \geq j}^{K} (m_i + h_i) \tag{7}$$

with nj being the number of mortgages that were neither prepaid nor censored before duration tj.

The corresponding estimator for the survivor function is:

$$S(t_j) = \prod_{i=1}^{j} \frac{(n_i - h_i)}{n_i} = \prod_{i=1}^{j} (1 - \lambda_i) \tag{8}$$

which is the Kaplan-Mier or product limit estimator for j=1 to K.

The time line is split into fixed intervals in the tabulation of the life table. A survival rate is then calculated for each interval. Let λi be the probability of prepayment at the ith interval. The actuarial actuarial estimator adjusts for censoring by subtracting one-half of the number of observations censored during the ith interval from the number entering the interval when calculating the fraction of completed spells.

The Parametric Model

The Weibull distribution is selected with the hazard function h(t) to be:

$$h(t) = \lambda p(\lambda t)^{p-1} \tag{9}$$

and the Survivor function S(t) to be:

$$S(t) = \exp(-\lambda t)^{p} \tag{10}$$

The Weibull distribution is proposed for the study, since it allows for the duration dependence captured by the parameter p. The duration dependence means that the hazard rate can be increasing or decreasing. If the duration dependence factor p=1, the duration follows an exponential distribution in which the likelihood of prepaying is constant with time.

The hazard rate is defined as an exponential function of covariates:

$$\lambda(t) = \exp(-\beta' x_i). \tag{11}$$

The hazard function can be further transformed such that:

$$y_i = \ln T_i = \sigma w_i + \beta \tag{12}$$

where:

$$w = (\ln T - \beta)/\sigma \tag{13}$$

$\lambda = e^{-\beta}$ and $\sigma = \frac{1}{p}$. Allowing for censoring due to incomplete spells observed on the last date of our sample period, the likelihood function is:

$$L = \prod_{i=1}^{N} [\sigma^{-1} \exp(w - e^w)]^{\delta_i} [\exp(-e^w)]^{-\delta_i} \tag{14}$$

where δ_i is the censoring indicator (1 if complete, and 0 if censored). The expected duration is simply the reciprocal of the hazard rate:

$$E[t] = \frac{1}{\lambda(t)} = \exp(\beta' x_i) \tag{15}$$

Variables

Given that most households prepay their mortgages when they sell their flats, we modelled the motivation to prepay and the prepayment rate against four categories of independent variable: the borrower, property, loan, and macroeconomic explanatory variables. Most of the variables included in the model are motivated by previous studies on household mobility and prepayment risk. The descriptive statistics of the variables are provided in Table 1 in the Appendices.

Borrower Explanatory Variables

Following the past literature, borrower specific characteristics such as race, household size, and the age of the buyer are included in the model, since they have a significant influence on the prepayment rate (LaCour-Little, 1999; Quigley, 1987; Giliberto and Thibodeau, 1989; Archer, Ling and McGill, 1996). In this study, the gross household income (GHHINC), as inspired by

LaCour-Little (1999), Peters, Pinkus, and Askin (1984), and Gilberto and Thibodeau (1989), was replaced by the household income level of household, so that we can account for inflation and the relative changes in income over the study period. Household income level (INCLEV) is the ratio of the annual gross household income adjusted for inflation to the average household income of the country at the point of purchase, which is represented by:

$$INCLEV = \frac{GHHINC_n}{AVEHHINC_n} \tag{19}$$

where GHHINCn is the real annual household income at year n and AVEHHINCn is the average household income in year n derived from the annual GDP at the point of purchase.

Property Explanatory Variables

Property specific data cover the description of the property, including the type of flat, the floor-level, and the age of a flat, as put forth by Ong (2000) and Hakim (1994) in their modelling of prepayment risk. Since the average age of flats in Toa Payoh is 24 years old, many flats have participated in the Main Upgrading Programme (MUP). This programme is aimed to improve the flats, blocks, and common areas of HDB estates at a cost to each household. Hence, the effective age, size, and value of a property will be affected. This will further spur the motivation to sell and hence prepay. Thus, a dummy variable for the MUP before sale is included. The date of announcement is used as the benchmark because the announcement is likely to trigger off changes in price.

Loan Explanatory Variables

Loan specific information includes the initial loan-value ratio (LV), motivated by Deng (1997), and the spread between the public and private interest rates. LV is computed by dividing the loan amount by the appraised value or purchase price, whichever is lower. It is assumed the valuation is equal to the price transacted when no valuation is available.[2] The maximum loan-to-value ratio is 80%, and the purchaser may assume a loan of up to 80% of the purchase price or valuation, whichever is lower. The spread between the public interest rate and the private housing loan rate for a 15-year loan at the point of prepayment or on the censored date (INTDIFF) is included.

2 This was especially true in the earlier years, when valuation was not required. The assumption is valid as long as flats of same classification are resold at similar prices and the market is very stable during the earlier period.

The market premium (PREMIUM) is included in the model, and is defined as the difference between the price and the valuation of property, divided by the valuation. The premium paid is captured at the point of the purchase of a flat. A higher premium paid implies a greater demand for the unit, since any premium must be paid in cash.

Macroeconomic Explanatory Variables

Next, we specified the set of macroeconomic variables to capture the changes in the environment. The change in GDP per household (CGDP) is also included to proxy the change in income over the holding period (Gilberto and Thibodeau, 1989; Dickenson and Heuson, 1992; Zorn and Lea, 1989). As motivated by Ong (2000) and Ong, et al. (2002), we used the changes in the Stock Exchange of Singapore Index (SES) to proxy for the sentiment in the market, as property prices tend to lag the stock market. The changes in the index (CSES) also reflect the returns on other investments (Zorn and Lea, 1989). In addition, following the models generated by Gilberto and Thibodeau (1989), Dickenson and Heuson (1992) and Ong, et al. (2002), we tested impact of the volatility in the mortgage rate (SMORTVOL). The volatility is measured by the standard deviation over a four-year rolling window. Similarly, the private housing price volatility (SPRICEVOL) and HDB housing price volatility (HDBVOL) are also measured by the standard deviation of the private housing price index over a four-year rolling window.

In addition, the expected returns of private and public housing are generated at the time of sale or the censored date, using the adaptive, rational, and exogenous expectations methodology. The returns of private housing are included because findings in the research of Tu, et al (2002) and Ong and Sing (2002) implied the upward mobility of households from public housing to private housing. Under the adaptive expectation methodology, the expectation of the price in the next quarter is formulated as follows:

$$MYOPTE\_5_t = \frac{1}{5} \times \left(\begin{array}{l} \frac{RPI_{t-1} - RPI_{t-2}}{RPI_{t-2}} + \frac{RPI_{t-2} - RPI_{t-3}}{RPI_{t-3}} + \frac{RPI_{t-3} - RPI_{t-4}}{RPI_{t-4}} + \\ \frac{RPI_{t-4} - RPI_{t-5}}{RPI_{t-5}} + \frac{RPI_{t-5} - RPI_{t-6}}{RPI_{t-6}} \end{array} \right) \quad (20)$$

and:

$$MYOPUB\_5_t = \frac{1}{5} \times \left(\begin{array}{l} \frac{HDBPR_{t-1} - HDBPR_{t-2}}{HDBPR_{t-2}} + \frac{HDBPR_{t-2} - HDBPR_{t-3}}{HDBPR_{t-3}} + \\ \frac{HDBPR_{t-3} - HDBPR_{t-4}}{HDBPR_{t-4}} + \\ \frac{HDBPR_{t-4} - HDBPR_{t-5}}{HDBPR_{t-5}} + \frac{HDBPR_{t-5} - HDBPR_{t-6}}{HDBPR_{t-6}} \end{array} \right) \quad (21)$$

where $MYOPTE\_5_t$ is the expected return of the private housing in quarter t and $MYOPUB\_5_t$ is the expected return of public housing at quarter t. The choice of finding the average expected returns over six quarters was motivated by Tu and Wong (2001), who found that there are no significant differences between the different user cost measurements differentiated by the different quarters (from two quarters to six quarters) believed to form the price expectation.[3] On the other hand, the expected return from both public and private housing is the inflation rate at the time of sale or prepayment, or the censored dated, as represented by EXO_1. The rational price expectations of HDB returns (RATPUB) and (RATPTE) in quarter t were obtained by the following:

$$RATPTE_t = \frac{(RPI_{t+1} - RPI_t)}{RPI_t} \quad (22)$$

and:

$$RATPUB_t = \frac{(HDBPR_{t+1} - HDBPR_t)}{HDBPR_t} \quad (23)$$

Analysis of Results

The Non-Parametric Model

Table 2 shows the Cutler and Ederer life table estimation of the duration (DUR). The table shows that the most moves occurred between 23 and 47

3 The results remained unchanged when average expected returns over five and four quarters were used.

months (1.91 years[4] to 3.91 years). This is due to the HDB's two and a half-year resale restriction policy. The hazard rate reached a maximum of 0.99% between 94 months to 118 months (7.83 years to 9.83 years). It should be noted that the overall mobility rate is quite low. Figures 1 and 2 show the estimated survival function and the graphical representation of the Kaplan-Meier Hazard function. Interestingly, the hazard rate seemed to decline from 100 months (8.3 years) to zero by 120 months (10 years). The reason for this may be that borrowers are waiting for the MUP or Selective Enbloc Sale (SERS). The graph also shows that the majority of prepayments occur at 150 months, which is approximately 12.5 years. The hazard rate is expected to peak at the end of the loan term

Parametric Analysis

Four tests were conducted separately to analyse the impact of the expected prices formed by the other methodologies, and to study the impact of expected price changes on the decision of borrowers to move and prepay. The actual realised return is included in the model in the first test, Test 1, so that we can compare its results with those of other tests that utilised the respective expected return variables. For the completed sales data, the actual return realised from the sale of property is:

$$ACTGAIN = \frac{(\text{Purchase Price} - \text{Sale Price})}{\text{Purchase Price}} \tag{24}$$

For households that have not sold their dwellings within the test period, we used the change in the HDB price index to proxy the realized gains accrue to them at the censored date.

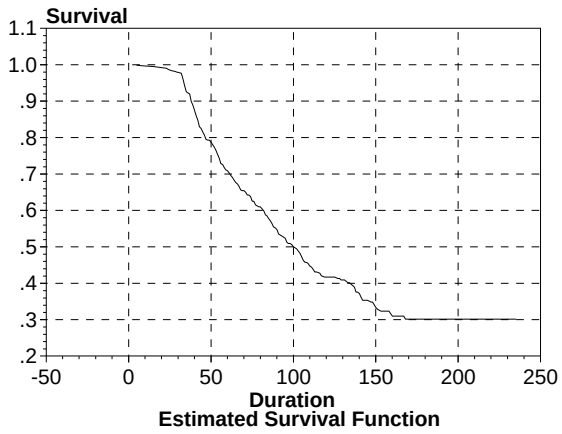
In Test 2, the average expected returns over the past six quarters were computed using the adaptive methodology, as motivated by Tu (2001). In Test 3, the expected returns were computed over a quarter, using the rational methodology. In the final test, Test 4, the expected returns of housing were assumed to be formed independently of the housing market's past performances; the inflation rate was used to proxy the expected returns of housing.

In addition, several preliminary tests were also conducted to remove variables that were highly correlated with other variables in the model, or

4 Although there is a stipulation that households can only relocate after two and a half years, there are households that are forced to move due to their persistent default of loan commitments and the carrying out of unlawful activities in their HDB dwellings. Such instances are, however, rare because the cost of the flat is heavily subsidized and the authorities are very sympathetic to the affected owners.

were highly insignificant. The results are provided in Table 3 in the Appendices. Using the likelihood ratio test, we found that at least one variable in all four tests is significant and improved the performance of the model. It was also observed that the average hazard rate is about 0.9% for all tests except Test 4, and is significantly different from zero. In other words, there is a 0.9% probability that prepayment will occur in a particular month.

Figure 1: Estimated Survival Function (Non-Parametric)



It is acknowledged that the Cox semi-parametric model was not used to test the decision of households to move and prepay. Although the semi-parametric model has no untenable distribution assumptions and lends itself to plenty of diagnostics, the semi-parametric form cannot readily handle 'ties'. In addition, the proportional hazard model is only appropriate with competing risks only if such risks are independent.[5] Alternatively, all of the parametric tests showed that the data exhibits a significant positive dependence (p>1), showing that the Weibull model is appropriate. The estimated survival function plotted in Figure 3 also resembles that in Figure 1. The estimated hazard rate depicted in Figure 4 is similar to increasing the Kaplan Mier hazard function in Figure 2.

5 The Semi-Parametric Duration Model specifies that $\lambda(t_i) = e^{-\beta X_i}\lambda_0(t_i)$, where $\lambda(t_i)$ is the hazard rate, $\lambda_0(t_i)$ is the baseline hazard rate, and βX_i is the respective coefficients and the covariates.

Figure 2: Kaplan-Meier Hazard Function

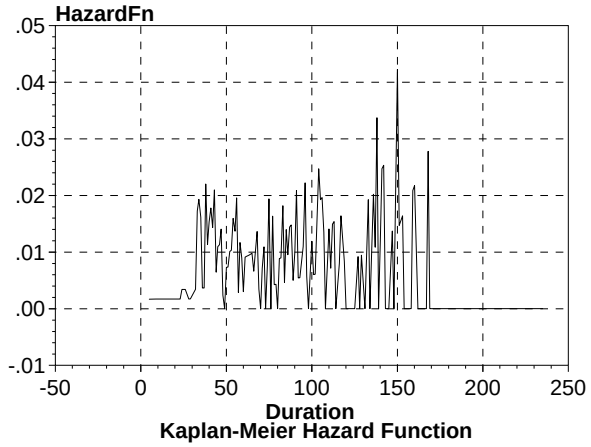
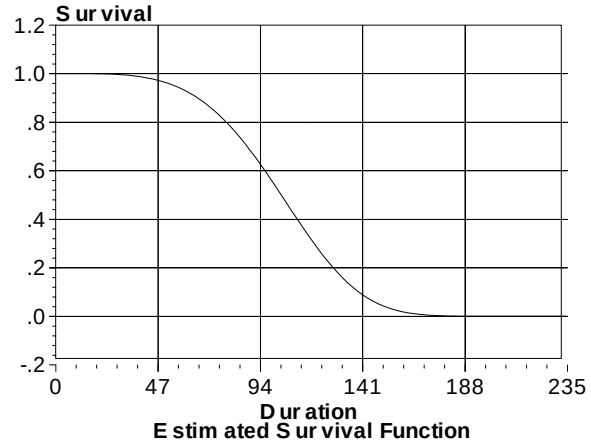


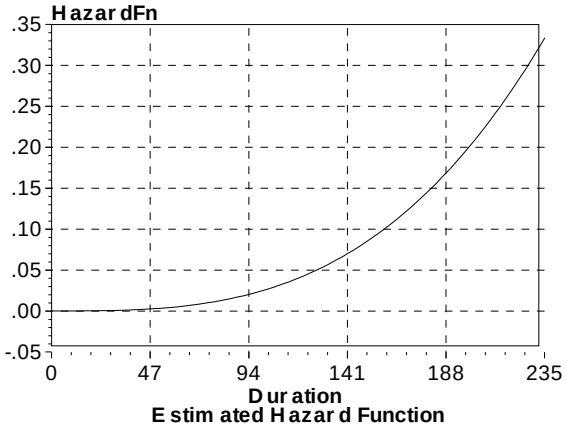
Figure 3: Estimated Survival Function (Parametric)



The results showed that the actual realisable capital gains of households are negatively related to their length of stay. These results differ from those of Davis and Pickles (1991). Davis and Pickles found that the capital gains obtainable from the sale of households' dwellings do not have a significant influence on the decision of households to move. The results also showed that the relationship between the actual realisable returns accruing to households and the households' duration of stay differs from that between the expected return of public housing and the households' duration of stay. A likely explanation for this difference is that both actual realisable gains and expected gains are computed against different periods. Although the

realisable return is useful in discerning whether buyers move or prepay, the measure is difficult to operationalise because buyers' realisable capital gains depend on the actual dates of move or prepayment. The ex-post nature of the variable makes it difficult for the industry to determine whether the returns are sufficient to motivate the household to move and prepay. In addition, the dates of purchase are idiosyncratic to each borrower.

Figure 4: Estimated Hazard Function



The results of Tests 2, 3, and 4 showed that the adaptive and rational expected returns for public and private housing have the same signs in the tests. Under the adaptive expectations assumptions, the returns from mortgagors' dwellings are positively related to their lengths of stay. Alternatively, the expected returns from the private housing market are negatively related to borrowers' lengths of stay. The results are interesting because they imply that the supply of resale flats will fall when the returns from the resale flats are relatively high in the past quarter, assuming that all other variables remained unchanged. In addition, the significant relationship between expected returns from the private sector and the length of stay also implies that both markets are related, which is consistent with previous studies on the cointegration between private and public markets (Ong and Sing, 2002).

The results under the rational expectation assumptions are mixed. On one hand, the rational expected returns from the public housing sector are significant at the 5% level. Interestingly, the expected returns based on the assumption of adaptive expectation also worked well. Yet the expected returns under both rational and adaptive assumptions have a relatively low correlation of 0.238. A possible explanation for this finding is that expectations formed using past prices affect the decision of households to

move, which is further reflected in the price. These results are consistent with those of He and Liu (1999).

On the other hand, the rational expected returns from the private housing sector are insignificant. It is not surprising that the expected private returns, using the rational expectation assumptions, are insignificant because the real estate market is inefficient. However, the results offer an interesting contrast to the relationship between public market returns and households' lengths of stay. The results implied that both private and public housing market mechanisms are different, and both markets are at different levels of efficiency. A possible interpretation of the results is that households form their expectations on past prices, which in turn affect their decision to move/prepay. However, their decisions do not influence returns for the next period. This is likely because we are only analysing households that are living in resold HDB flats.

It is acknowledged that the returns here refer only to the capital returns of housing, and do not include rental returns. However, given that the rental market is relatively smaller than the owner occupier market, the impact of rental returns is likely to be negligible. Further likelihood ratio tests were conducted, and the restricted models consist of all the variables except the expected return variables. The likelihood ratio tests showed that at least one of the variables, the expected returns of public and private housing, has been significant in improving the performance of the models in Tests 2 and 3. However, there is no evidence that the expected returns of housing computed using the exogenous expectation methodology improved the modelsmodel, as shown in Test 4. Furthermore, the exogenous expected return was found to be insignificant in influencing borrowers' lengths of stay. The application of the exogenous expectations methodology is likely to be too restrictive in explaining the formation of borrowers' expectations.

Our results also showed that the relative price of private housing with respect to public housing is positively related to borrowers' lengths of stay. In other words, households will tend to stay if the price differential between private housing and public housing widens. This result implies that the gains accrued to the house owner from the sale of a dwelling are influential in his decision to move and prepay.

Most borrower specific variables – buyer's age, race, household size – are insignificant, as opposed to the findings by Davis and Pickles (1991) and Knapp, White, and Clark (2001). However, the income level of households is significantly and negatively related to borrowers' lengths of stay, which is consistent with past studies in both the prepayment and mobility literature. The results for the property specific variables are mixed. The main upgrading programme was found to be highly insignificant in affecting

borrowers' lengths of stay, and was removed in the preliminary test. Flat type also did not seem to have a significant impact on borrowers' lengths of stay. However, the results showed that older flats tend to have a positive influence on the borrowers' length of stay. One likely reason is that borrowers may find it harder to sell older flats compared to newer flats.

Alternatively, the loan specific and macroeconomic factors appeared to perform better. A separate test [6] showed that public mortgage rate movements are negatively related to borrowers' lengths of stay. This result contradicts previous studies that focused on Fixed Rate Mortgages. A likely reason for the above relationship is that mortgagors may find private mortgage rates more attractive when public mortgage rates rises, which induces them to move. The significant positive relationship between the mortgage rate spread and borrowers' lengths of stay in all the subsequent tests further avowed the reasoning. However, the borrower is likely to stay longer if the loan he took out had a lower loan-to-value ratio, which would be consistent with the findings by Deng (1997).

Interestingly, the change in the GDP over the duration of stay, which was also used as a proxy for income growth, is positively and significantly related to borrowers' lengths of stay. The result contradicts the findings in the prepayment literature (Dickenson and Heuson, 1992; Peters, Pinkus, and Askin, 1984; Phillip, Roseblatt, and Vanderhoff, 1996; and Gilberto and Thibodeau, 1989) and the mobility literature (Pickles and Davis, 1995). It is likely that most households use the additional income for consumption rather than for housing. Given that the average sample household income level is below the national average, investing in housing is not possible with an increment in income without an increase in wealth. Ong (2000) also discovered a similar relationship in his study. The change in the stock index, which is used to proxy the returns of alternative assets, is negatively related to households' lengths of stay, but the relationship is insignificant. Alternatively, the price volatility of private housing is positively and significantly related to mortgagors' durations of stay. Similarly, in a separate test (results are not shown), the price volatility of public housing had a positive and significant relationship to mortgagors' durations of stay. The volatility of public and private housing prices are tested separately because both variables are closely related and may lead to compounding errors if both variables are tested concurrently.

6 A similar parametric test was conducted with the same variables except the interest differential variable. Results are not shown, but are available upon request.

Conclusion

This study set out to determine the relationship between the decision of mortgagors to prepay/move and the expected returns of their dwellings and of other forms of dwelling. In addition, the study attempts to provide insight into the prepayment risk of Singapore's subsidised mortgages. Since the prepayment risk of the adjustable rate mortgages is directly related to the decision of mortgagors to move, we further tested the variables against mortgagors' lengths of stay. The expected returns of mortgagors' dwellings and those of other forms of housing were computed in accordance with the definitions of the adaptive expectation hypothesis, rational expectation hypothesis, and exogenous expectation hypothesis. The results showed that the expected return of a resale flat is significantly and positively related to the mortgagor's duration of stay, under both the assumptions of the adaptive and rational hypothesis. The expected returns of private housing, however, are negatively and significantly related to mortgagors' lengths of stay. Our results are consistent with the findings of Case and Shiller (1988) that households do form their expectations of the appreciation of housing prices from changes in price during the period before they sold their dwellings.previous period. Our results are also consistent with He and Liu's findings in this aspect; expected property price increases will have a negative impact on price. It is the belief of a rise in prices, followed by a further rise in price, that entices borrowers to delay their prepayment decisions.

The findings of this paper also provide several new insights. First, it is surprising to find that the expected returns of public housing formed under the assumptions of the rational expectation hypothesis are significant, since the real estate market is supposed to be inefficient and the resale HDB market is greatly affected by continual changes in governmental policies. In additional, the expected returns formed under the assumptions of the adaptive expectation hypothesis are significant. Muth (1961) showed that the adaptive expected return can be the same as the rational expected return for goods that can be stored. This is because the purchaser will buy more to store lest prices will increase. Although housing cannot be stored, the owner may behave analogously to the purchaser in Muth's (1961) analysis. In the hope that the returns of housing will increase in the future, owners can continue to wait for the higher prices, especially if they have no obligation to sell early.

The results further showed that the rational expected returns for private housing do not have a significant relationship with the decision of mortgagors to move/prepay, although the adapted expected returns are negatively and significantly related to mortgagors' lengths of stay. It has been noted that the dwellings available in the private housing market are more heterogeneous than HDB flats, and the volume of transactions

involving private dwellings are less than that in public housing, given that the majority of the population in Singapore lives in HDB flats. In other words, the government's interventions, in the form of cheaper financial costs, lower entry costs,[7] and greater homogeneity in design, could have ironically improved the efficiency of the market.

From an operational point of view, the results showed that it is important for all parties in the secondary mortgage market to monitor the past returns of each housing sector and the closeness of the price levels between different housing sectors. In addition, mortgagors' race and age appear to be less significant than the level of prepayment risk.

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7 Resale HDB flats are cheaper than private housing. In addition, given that the households in the sample were not affected by the new Oct 2002 CPF rulings, they could use their CPF savings to pay the down payments for their flats.

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Appendices

Table 1

VARIABLE	MEAN	STD. DEV.	MINIMUM	MAXIMUM
BUYERAGE	38.48	10.98	21	79
MAL	.138	.345	0	1
IND	.488	.216	0	1
OTHERS	.505	.709	0	1
JOINT	.786	.41	0	1
HHOLD	3.133	1.45	1	7
INCLEV	.770	.522	0	3.93
FLOOR	8.65	5.48	1	25
R3	.539	.499	0	1
R4	.335	.472	0	1
MUP	.318	.466	0	1
BLDGAGE	24.213	4.909	8.75	33
PPRICE($)	115,423	89,735	20,000	800,000
SPRICE($)	97,261	126,100	0	750,000
LOAN ($)	63,401	56,516.7	1800	328,000
LV (%)	57.3	21.4	22.9	90
OUTSTAND($)	21,525.29	37,206.96	0	287,346
DUR(Months)	80.476	43.6447	5	235
PREMIUM (%)	51.3	10.11	-28.9	56
SMORTVOL(%)	.556	.202	.19	1.55
HDBVOL	43.498	17.455	0	80.6
CSES	.375	.549	-.554	2.289
CGDP	.721	.580	-.321	2.917
INTDIFF(%)	4.299	1.297	2.09	9.69
ACTGAIN	.728	1.407	-1	18.4805

Notes to Table 1:

The data for this study was provided by a HDB Branch Office of Singapore. From a total of 37,000 units in Toa Payoh, a sample of 594 resale mortgages spanning a period from 1982 to 2000 was observed. The buyer characteristics are the age of the buyer (BUYERAGE) and the dummy variables for Malays (MAL) and Indians (IND), and others (OTHERS). Other buyer characteristics include the size of the household (HHOLD) and the household's income level (INCLEV). The household's income level was computed by normalizing the reported household income with the overall household income adjusted to 1990 prices. The property related variables include dummy variables of 3-room (R3) and 4-room (R4) flats, the age of the units (BLDGAGE), and the dummy variable for the Main Upgrading Programme (MUP). The loan characteristics are the loan-to-value ratio (LV), the private mortgage volatility rate at the point of sale (SPMORTVOL), and the spread between the public and private rates (INTDIFF). Other variables include the purchase price (PPRICE), the selling price (SPRICE), and the premium, which is the amount paid above valuation and the date of originations and prepayments. The macroeconomic factors include the changes in the SES index (CSES), changes in the GDP (CGDP), changes in the HDB mortgage rate (CHDBMR), changes in the HDB index (CHDBPR), and the HDB's price volatility (HDBVOL).

Table 2: Cutler and Ederer Life Table Estimation of the Duration

Survival		Enter	Censored	At Risk	Exit	Survival rate		Hazard Rate	
.0-	23.5	594	0	594	6	1.0000	(.000)	.004	(.000)
23.5-	47.0	588	54	561	107	.9899	(.004)	.0090	(.001)
47.0-	70.5	427	74	390	73	.8011	(.017)	.0088	(.001)
70.5-	94.0	280	51	254	47	.6511	(.021)	.0087	(.001)
94.0-	117.5	182	28	168	35	.5309	(.023)	.0099	(.002)
117.5-	141.0	119	26	106	12	.4209	(.025)	.0051	(.001)
141.0-	164.5	81	30	66	12	.3727	(.026)	.0085	(.002)
164.5-	188.0	39	30	24	1	.3049	(.027)	.0018	(.002)
188.0-	211.5	8	7	4	0	.2922	(.029)	.0000	(.000)
211.5-	235.0	1	1	0	0	.2922	(.029)	.0000	(.000)

Source: Author's computation

Table 3: The Parametric Duration Test
Dependent Variable: Log Duration

	TEST 1 (Using Actual Returns)		TEST 2 (Using Adaptive Expectation methodology)		TEST 3 (Using Rational Expectation methodology)		TEST 4 (Using Exogenous expectation methodology)	
	Coeff	P	Coeff	P	Coeff	P	Coeff	P
Constant	2.1870	.0000	2.0481	.0000	2.1744	.0000	1.7614	.0000
BUYERAGE	-0.3104	.9868	-0.6361	.7310	-0.6142	.7516	-0.6878	.8085
MAL	-0.1007	.1592	-0.8821	.1249	-0.7417	.1867	-0.3511	.2012
IND	-0.5986	.3275	-0.6805	.2850	-0.4573	.4786	-0.7696	.4228
JOINT	-0.2980	.0000*	-0.2934	.0000*	-0.3079	.0000*	-0.2473	.0070*
HHOLD	-0.1734	.2554	-0.1422	.3710	-0.6232	.6853	-0.9061	.3027
INCLEV	-0.8084	.0430**	-0.6925	.0877**	-0.9227	.0162*	-0.1505	.0027*
PREMIUM	-0.2602	.1388	-0.2821	.1249	-0.1592	.3757	-1.6126	.0001*
LV	-0.9465	.3906	-0.1170	.2992	-0.1739	.1108	-0.6424	.0001*
INTDIFF	0.1953	.0000*	0.1962	.0000*	0.1775	.0000*	0.3287	.0000*
SMORTVOL	1.4863	.0000*	1.5923	.0000*	1.5487	.0000*	1.6281	.0000*
R3	-0.1438	.1354	-0.7517	.2778	-0.1148	.1871	-0.3576	.0001*
R4	-0.3701	.5611	-0.4021	.9491	-0.1029	.8733	-0.1364	.1188
BLDGAGE	0.1430	.0005*	0.1288	.0063*	0.1331	.0010*	0.3485	.0000*
SPRICEVOL	0.1239	.0000*	0.1030	.0000*	0.1344	.0000*	0.2902	.0000*
CSES	-0.1071	.1456	-0.7133	.2748	-0.7894	.1347	-	-
CGDP	1.0870	.0000*	1.0228	.0000*	1.0473	.0000*	-	-
RELPI	0.5746	.0641**	-	-	-	-	-	-
ACTGAIN	-0.2417	.0002**	-	-	-	-	-	-
MYOPTE_5	-	-	-3.6967	.0001*	-	-	-	-
MYOPUB_5	-	-	3.0805	.0006*	-	-	-	-
RATPTE	-	-	-	-	-1.2067	.3123	-	-
RATPUB	-	-	-	-	0.3414	.0015*	-	-
EXO_1	-	-			-	-	11.1554	.2313

* Significance at the 1 per cent level; ** significance at the 1 per cent level.

Notes to Table 3:

The data for this study was provided by a HDB Branch Office of Singapore. From a total of 37,000 units in a constituency, a sample of 594 resale mortgages spanning a period from 1982 to 2000 was observed. The buyer characteristics are the age of the buyer (BUYERAGE) and the dummy variables for Malays (MAL) and Indians (IND). Other buyer characteristics include the size of the household (*HHOLD)* and the household's income level (*INCLEV)*. The household's income level was computed by normalizing the reported household income with the overall household income adjusted to 1990 prices. The property related variables include dummy variables of 3-room (R3) and 4-room (R4) flats and the age of the unit *(BLDGAGE)*. The loan characteristics are the loan-to-value ratio (LV) and the payment-to-income ratio (*PAYINC*). Other variables include the date of originations (*PDATE*) and the amount paid over the valuation (*PREMIUM)*. The macroeconomic factors include the change in the SES index (*CSES*), changes in the GDP (*CGDP*), changes in the HDB mortgage rate (*CHDBMR*), changes in the HDB index (*CHDBPR*), the HDB public rate at the point of sale (*SHDBINT*), changes in the private residential price index (*CRPI*), and the private mortgage volatility rate at the point of sale (*SPMORTVOL*). *RATPTE* and *RATPUB* represent the expected returns of private and public housing using the rational expectations methodology. *MYOPTE_5* and *MYOPUB_5*

represent the expected returns of private and public housing using the rational expectations methodology. *EXO_1* represents the expected returns of private and public housing using the exogenous expectations methodology.

The hazard rate is: $h(t) = \lambda p(\lambda t)^{p-1}$

where $\lambda(t) = \exp(-\beta' x_i)$.

Lambda	*0.00897*	*0.00902*	*0.00890*	*0.00752*
P	4.03332	4.12865	4.04179	2.38059
Log-likelihood without variables on expected returns		144.8824	144.8824	-333.4458
Log-Likelihood	-136.8495	-126.7102	-134.2864	-331.7604
Sig. at the 5% level of significance	Yes	Yes	Yes	No

Notes: The log-likelihood for a model without coefficients is -547.7889. Hence, the likelihood ratio test shows that at least one variable is significant in all four tests.