

DELINQUENCY RISK IN RESIDENTIAL ARMs

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ABSTRACT

Delinquency risk is a major area of concern to real estate mortgage lenders and potential issuers of Mortgage-backed Securities (MBS). This paper provides the first rigorous analysis of residential adjustable mortgage delinquency in Singapore. By studying 633 individual mortgages from 1980 to 1999, it is found that delinquency risk is dominated by macroeconomic factors and several mortgage loan specific factors. In particular, market sentiment, change in mortgage rate and the premium of mortgage over investment rates have a positive influence on delinquency, while change in unemployment rate, capital appreciation of residential properties and housing rentals exerts a negative impact. However, the direction of influence of the change in economic growth is unclear. Generally, property-specific and borrower-specific characteristics do not have a statistical significant impact on delinquency risks. It is also discovered that rate of delinquency and the performance of the economy have a consistently negative relationship. Consistent with the finding that macroeconomic factors exert the greatest impact on delinquency risk, lenders' abilities to reduce the overall risks of delinquency in their mortgage portfolio are limited. Potential issuers of MBS will also likely find it difficult to package the securities to reduce such risks.

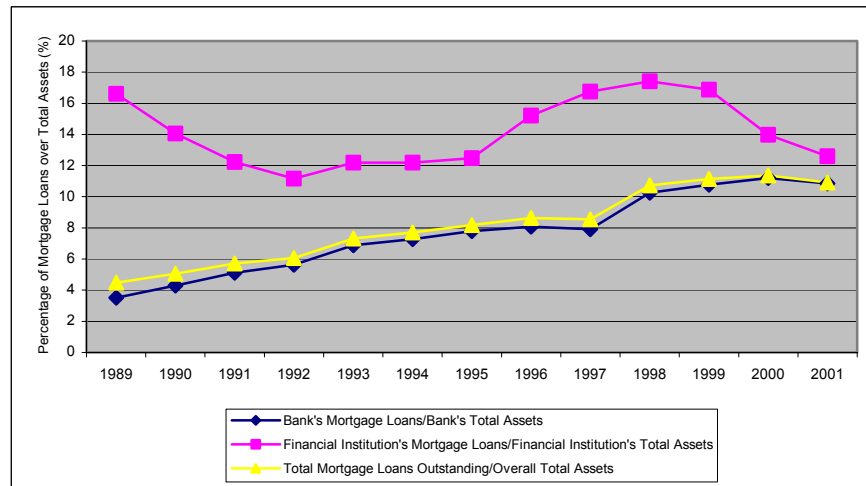
Key words: Delinquency risk, residential adjustable mortgage.

INTRODUCTION

Mortgage lending is an imperative component of the businesses of financial institutions worldwide. This is accelerated by the growth of the private residential property markets in the respective countries. Consequently, the amount of mortgage loans originated by banks and financial institutions has accordingly increased. Thus, an increasing volume of Mortgage-backed Securities (MBS) would continue to be issued.

Similar trends can be found in Singapore (see Exhibit 1). In 1998, the Monetary Authority of Singapore, the de facto central bank, recommended the securitisation of real estate (Sing and Ong, 2003). Together with the provision of favourable tax treatment (Ong, Ooi and Sing, 2000), there is enormous potential for the securitisation of real estate and real estate-related debt in Singapore.

Exhibit 1: Proportion of mortgage loans outstanding to total assets of banks and financial institutions (1989-2001)*



* Financial Institutions account for a low proportion (about 4% in 2001) of the market share.
 Source: Monetary Authority of Singapore's Monthly Statistical Bulletin Database

According to Campbell and Dietrich (1983), at any point of time, possible borrower action can be categorized into one of four groups:

1. Delinquent (delay payment);
2. Default;
3. Prepay the mortgage (through the sale of property or refinancing);
4. Continue to service the mortgage.

Quercia and Stegman (1992) described the assumption in borrower payment models that the utility derived from each of the actions is assessed and compared separately by the borrowers. Subsequently, the borrowers will select the action that yields the highest utility. Thus, a comprehensive view of the factors influencing each of the possible borrower actions is essential towards the understanding of overall mortgage risk. Prior research predominantly focuses on the study of mortgage defaults or prepayments. On the other hand, there is generally a lack of studies on mortgage delinquency. This represents a gap in existing knowledge of mortgage risk. This paper attempts to fill this gap by examining the nature of delinquency risk and the factors affecting their intensity.

It is also imperative to note that the essential preceding step of a defaulting mortgage is delinquency. By providing insights to delinquency risk, this paper serves to expand the current perspectives and understanding of mortgage defaults in

the existing literature. On the other hand, in the case when a loan becomes delinquent, default might not necessarily follow (Waller, 1988). This suggests that studies on delinquency risk can be an imperative area of research that contributes to the current knowledge of overall mortgage risk.

Prepayment/ default rates may be low if the portfolio of mortgages or securities backed by mortgages are well packaged. However, delinquency may occur even if the mortgages are of high quality. This occurs when the mortgagee requires the money for the principal and interest repayments to meet other financial obligations. There are fundamental differences in the motivations for prepayment, default and delinquency. This further suggests the importance of investigations into the latter.

The characteristics of the mortgages will affect the pricing and packaging of MBS. Thus, the results of this paper will be of interest to issuers, underwriters and potential investors of MBS.

The key results of this study are that property and borrower specific characteristics generally do not have significant impacts on delinquency risks. Instead, the most influential determinants consist of the macroeconomic factors and several mortgage loan factors. Specifically, market sentiment, the change in mortgage rate and the premium of the mortgage over investment rates have a positive influence on delinquency, while change in unemployment rate, capital appreciation of residential properties and housing rentals exert a negative impact. The direction of influence exerted by the change in economic growth is unclear.

The next section provides a review of related literature followed by a description of the research methodology for the intended probit/logit analysis. The data and its descriptive statistics are then explained before the findings of the results are presented.

LITERATURE REVIEW

The various forms of risks associated with home mortgages and the factors influencing these risks have been a focus of research in the finance literature in the past few decades. However, studies on mortgage delinquency are limited. Von Furstenberg and Green (1974) attributed this anomaly to the lack of suitable available data that is required to undertake such analyses.

Due to the fact that a default/foreclosed mortgage loan must first go through delinquency, there is an obvious relationship between these forms of risk. For instance, Waller (1989) found that a lengthy delinquency period might cause borrowers to accumulate so much back payments that default becomes unavoidable. Campbell and Dietrich (1983) found that most of the determinants that affect default decisions influence delinquency decisions in the same way. Additionally,

Waller (1988) observed that most works do not clearly distinguish between the factors affecting delinquency and default. Thus, the usefulness of studies on default/foreclosure risks towards our study is substantiated.

However, it is important to be aware that the motivations for delinquency and default are essentially different. For instance, Campbell and Dietrich (1983) did a comparison between the determinants of delinquency and default rates and verified that household income and interest rate are more influential than equity measures. They also expected the loan-to-value ratio to be less important than for default incidence, because delinquency is without potential termination of ownership of the property, although their results differ.

It is also necessary to note that most literature on mortgage risks was originated from the US, where Fixed Rate Mortgages (FRMs) are prevalent (Ong, 2000). Conversely, all mortgages originated in Singapore are Adjustable Rate Mortgages (ARMs) (Khor and Ong, 1998). The exogenous and endogenous factors affecting both forms of mortgages may thus diverge. However, the level of divergence is expected to be slight. For instance, Zorn and Lea (1989) suggested that ARMs in Canada have a higher probability of default than FRMs in the US. Nonetheless, the methods and factors used in the literature to rationalize mortgage risks in FRMs serve as a platform for our analysis.

Determinants of mortgage delinquency

Ambrose and Capone (1996, 1998) and Waller (1988) described the aim of delinquency is either to put the funds, originally intended to pay the installments, to other uses due to financial difficulties, or to exercise the implicit put option to abandon the property. A third cause of delinquency noted by Waller (1988) is the economic incentive borrowers can gain from living in the house rent-free before foreclosure takes place.

Von Furstenberg and Green (1974) found that the equity-value ratio possesses a significant negative relationship with delinquency, while the age of mortgages has a positive relationship. They also discovered that mortgages of existing houses are more prone to delinquency than those taken on new houses. Besides von Furstenberg and Green (1974), Herzog and Earley (1970) and Morton (1975) also found income, occupation and the number of children to be influential determinants.

Zorn and Lea (1989) argued that delinquency could be regarded as a form of borrowing from the mortgage lender at the mortgage contract rate. Therefore, when the interest rate increases, delinquency rate will correspondingly rise as people “borrow” at the relatively cheaper source of funds to finance other uses. Canner et al. (1991) found that factors such as the receipt of government assistance, being headed by a minority and marital status have positive influences.

Canner et al (1991) also pointed out that delinquency prediction consists of a large unexplained random component as credit problems can arise from events that are difficult to foresee. Thus, the use of ex-ante data have the ability to capture components that systematically affect delinquency and are observable to the lender at loan origination, but ignores the more unpredictable ex-post components.

Determinants of mortgage defaults & foreclosure

Literature on mortgage loan specific characteristics traditionally focuses on the equity position of the borrower. Several proxies are used including the loan-to-value ratio at origination (Campbell and Dietrich, 1983), current loan-to-value ratio (Campbell and Dietrich, 1983; Cunningham and Capone, 1990), value-to-total debt ratio (Waller, 1988; Zorn and Lea, 1989; Springer and Waller, 1993) and book value (Giliberto and Houston, 1989; Hendershott and Schultz, 1993). Other mortgage loan specific factors used include the age of the mortgage (Waller, 1989; Schwartz and Torous, 1993), mortgage term (Bervoec et al., 1994) and mortgage rate (Zorn and Lea, 1989; Ambrose and Capone, 1996, 2000).

Property related factors examined include the price volatility of the property (Schwartz and Torous, 1993; Capozza et al., 1998; Ambrose and Capone, 2000), age (Canner et al., 1991; Hakim and Haddad, 1999) and neighbourhood quality (Vandell and Thibodeau, 1985). Other significant factors consist of the returns from property capital appreciation (Schwartz and Torous, 1993; Kau et al., 1994; Case and Shiller, 1996) and the returns from rental yield (Capozza et al., 1997, 1998).

With regards to borrower related characteristics, the payment-to-income ratio is a popular ability-to-pay measure but yields inconsistent results. Vandell (1978) and Campbell and Dietrich (1983) found a positive relationship, while other studies found a negative relationship (Springer and Waller, 1993; Cunningham and Capone, 1990). Other studies focus on the wealth of the individuals and household income (Canner et al., 1991; Bervoec et al., 1994), age (Capozza et al., 1997), and the number of years of job tenure (Cunningham and Capone, 1990; Hakim and Haddad, 1999).

Exogenous factors include demographic or macroeconomic factors (Dickinson and Hueson, 1994). Unemployment is the more popular factor used by a number of studies that include Campbell and Dietrich (1983), Lea and Zorn (1986) and Capozza et al. (1997).

DATA AND DESCRIPTIVE STATISTICS OF VARIABLES

This study attempts to determine the influencing factors of the rate of delinquency of mortgages. It is hypothesized that a mortgage will become delinquent when the borrower encounters financial difficulties or transfers the funds, initially budgeted to repay the principal and interest, to other financial commitments that have arose.

Exhibit 2 presents the list of determinants, the codes used and the expected signs of influence.

Mortgage loan specific characteristics

The first characteristic to be tested is the Loan-to-Value ratio (LVR) at the time of origination. A higher initial LVR implies a higher level of borrowings and indicates a lower financial ability of the borrower. The borrower is thus more likely to meet financial difficulties, which is further aggravated by the higher mortgage instalments.

Exhibit 2: List of determinants, codes and expected signs of influence

Variable	Code	Expected Signs
Mortgage Loan Specific Characteristics		
Loan-to-Value Ratio	LVR	+
Price Premium	PREMIUM	+
CPF-to-Price Ratio	CPFPRICE	-
Mortgage Term	MT	-
Change in Mortgage Rate	CMR	+
Premium of Mortgage Rate over Investment Rate	PREMR	+ / -
Property Specific Characteristics		
Tenure where 99-year Leasehold = 1	TENURE	-
Type of Property where Low-rise = 0	TYPE	+
Land Area	LAREA	+
Floor Level	FLOOR	+
Built-up Area	BUAREA	+
Purchase Price	PPRICE	+
Change in Rents	CRENTS	-
Borrower Specific Characteristics		
Payment-to-Income ratio	PINCRATIO	+
Number of Borrowers	BORROWER	-
Age of Youngest Borrower	AGE	-
Purpose of Purchase where Owner-occupation = 0	PURPOSE	+
Total Annual Income of Borrowers	INCOME	-
Number of years in current employment	YRSEMP	-
Environmental Characteristics		
Change in Unemployment Rate	CUNEMP	+
Change in STI	CSTI	+
Change in GDP	CGDP	-
Change in RPPI	CRPPI	-

The extent to which the purchase price exceeds its valuation is expected to have a positive impact on delinquency. If the borrower had spent an excessive amount of his savings on the property, he would have lesser cash savings to meet other financial commitments that may arise in the future. We use the Price Premium,

which is defined as the ratio of the difference of purchase price and valuation, over valuation.

It is highly probable that Central Provident Fund (CPF) funds will firstly be utilized to pay for the property before borrowing the rest of the purchase price, subject to certain stipulated limits. CPF is the mandatory savings scheme in Singapore where both the employer and employee contributes to the fund. The use of CPF funds thus reduces the cash savings required. This enhances the borrower's ability to meet any unexpected financial commitments. A higher CPF-to-Price ratio is likely to provide a lower incidence of delinquency.

Longer mortgage terms allow borrowers to have a greater ease of budgeting their expenditures over a longer period of repayment. The expected influence is thus negative. Another important determinant is the degree of change of the mortgage rates. Mortgage rate increases are measured by the difference between the mortgage rates at the date of origination with that at the date of delinquency or censor date if there is no delinquency.

The premium of mortgage rates over rate of returns of investments is expected to affect delinquency risk. As this premium decreases, there is increasing incentive for the borrower to reallocate funds from mortgage payments to other alternative investments. This occurs when the increase in the investment returns is dominant. Delinquency will thus increase. On the other hand, if the decrease in the premium is due to a decrease in mortgage rate, the consequent effect may become similar to that of the change in mortgage rate. As the mortgage rate falls relative to the investment returns, a lower financial stress is placed upon the borrower resulting in a lower risk of delinquency. We utilize the mortgage rates for each loan as at August 2002. The average 12-month fixed deposit rate is used as a proxy for the average returns of investments.

Property specific characteristics

The tenure of residential properties in Singapore is essentially categorized into either 99-year leasehold or freehold properties. Dummy variables are used to differentiate the effect of the type of lease (99-leasehold properties are allocated the value of 1; and otherwise are allocated 0). The properties can also be classified as either low-rise or high-rise. Dummy variables are again used where the latter is allocated the value of 1; and otherwise is allocated 0.

An independent variable that is used for low-rise properties is the Land Area. It is expected that as the land area increases, the property will become more expensive. A determinant for high-rise properties is the floor level the property is located (Ong and Koh, 2000). People generally prefer to live on higher floors resulting in higher costs. Delinquency risks are anticipated to be higher for such properties. Another variable used is the built-up area of the property.

The purchase price of the property will directly show how expensive the property is. It could also proxy neighbourhood quality, which is difficult to measure directly without much effort. The rental of a property is also expected to influence delinquency risk. For instance, when the rents are decreasing, the borrower-landlord's ability to meet the mortgage payments is affected since his cash flow has been disrupted. Since it is difficult to obtain the actual rents of each investment property, we shall use the percentage change in the residential rental index from the loan origination date to the date of delinquency or the date of censor if there is no delinquency.

Borrower specific characteristics

The Payment-to-Income ratio shows the ability of borrowers to pay the mortgage installments. The ratio at the time of origination is one of the criteria used by lenders to assess the credit worthiness of potential borrowers. Past works mostly indicate that the equity measure is more influential on default than the affordability measure. However, it is believed that the reverse will hold true for delinquency incidence. A higher payment-to-income ratio reflects a lower ability to pay the installments and a higher probability of facing financial difficulties. The initial annual mortgage payment and total annual income at the time of origination is used to calculate the ratio.

Purpose of purchasing the property can be categorized into either of owner-occupation or for investment. Since the initial motivations and final outcomes for purchase is different, the delinquency incidence is likely to be dissimilar. Investors of property are motivated by the profit motive and may take more risks leading to an inability to pay the mortgages when financial difficulties occur. They may also be dependent on the rents received to pay the mortgage. Owner-occupiers are more likely to have assumed less risk and be more motivated to continue to pay the mortgage when financial difficulties strike. Dummy variables are utilized to account for categories of purchasers where investors are assigned the value of 1, and 0 if otherwise.

The certainty of future flows of income is proxied by the number of years the borrower with the highest income has been in his current employment. Higher certainty would indicate better ability to continue with the mortgage payments. Other factors include the number of borrowers, age of the youngest borrower and the total annual household income.

Environmental characteristics

Retrenchments will affect borrowers' abilities to continue with the mortgage payments. The threat of retrenchments and certainty of future income can be measured by the change of unemployment rate from the origination date to the date of delinquency or if there is no delinquency, the date of censor is used. Another

variable used is the change in Gross Domestic Product (GDP), which is taken to proxy the change in income of the borrowers.

Market sentiments can proxy the returns on other investments (Zorn and Lea, 1989). When market sentiments are good, funds will be directed away from mortgage payment to other more attractive investments. Conversely, poor sentiments imply a lack of good investments that borrowers can park their money in. Accordingly, funds will be better used in repaying the mortgages to prevent incurring late payment penalties. This is similar to the argument put forth by Ong (2000) and Ong et al (2002), although the research was on prepayment rates. It is well noted that changes in property prices do reflect changes in fundamentals and sentiments (Ong, 2000; Ong et al, 2002). However, it is liable to lag the current market sentiments. Market sentiments are thus proxied by change in the Straits Times Index (STI) that is a price-weighted index consisting of the 30 major stocks in Singapore.

Capital appreciation of the property since purchase will affect the incentive of the borrower-investors to continue making mortgage payments. If the property has considerable capital appreciation since purchase, the borrower will be motivated to repay the mortgage conscientiously as their property represents a good investment or savings. However, if the property is worth less than its original cost, the borrower may view the property as a wrong or bad investment, with further mortgage payments representing a perpetuation of the wrong decision. The money could have been invested in other worthwhile investments. However, the capital appreciation is likely to have a much smaller impact on delinquency rates for owner-occupiers. As there is no information on the value of each property at the delinquency date or censor date if there is no delinquency, we shall utilize the change in Residential Property Price Index (RPPI) to determine the price change since origination date.

Descriptive statistics

The summary descriptive statistics is shown in Exhibit 3. Several data including CMR, CRENTS and CUNEMP, and the delinquency data like Delinquency Date and Duration Period, have two sets of data each to account for the two different definitions of delinquency that this study has utilized. For instance, CMR1 refers to the change in mortgage rate for loans under legal proceedings between January 1999 and July 2002 while CMR2 refers to 4-month delinquency cases over the period January 1999 to December 2001. Two definitions of delinquency are being investigated as there is no commonly agreed designation for delinquency. In addition, the motivations of being in 4-month delinquency may be different from that of being placed under legal charge.

Out of the 633 mortgages under study, a total of 21 cases have been under legal proceedings while 29 cases have a history of being in 4-month delinquency in their respective periods of analysis.

The origination dates of the sample range from March 1980 to December 1999. Since only 14 cases originated before 1991, a better measure of central tendency would be the median at 1998. This represents a lopsided spread of samples across 20 years with 405 cases or 63.98% of the 633 cases originated after 1998. The average delinquency dates for Delinquency Date1 is in 2001 while that of Delinquency Date2 is in 1999.

On average, once a mortgage has been issued a lawyer's letter (Duration Period1), it will take a period of around 148 days from the date of delinquency before the missed installments are repaid. The maximum delinquency period is 420 days. For 4-month delinquency cases, the average duration (Duration Period2) is 111 days, while the maximum delinquency period is 480 days.

The amount of loan released ranges from \$30,000 to \$1,640,000, while the average loan amount is \$364,682. The average valuation is \$670,357 with a higher range of \$147,000 to \$3,400,000. The consequent average LVR is 0.5655. PREMIUM is shown to range from -50% to 52.27% while the average value is 11.64%. The amount of CPF lump sum used by the borrowers range from zero (not used) to \$631,000. The resultant CPFPRICE ranges from zero to 92.21%. The average CPFPRICE is 17.26%. The average mortgage term (MT) is 24.0774 years, which range from 3 to 33 years. The breach of the stipulated maximum loan term of 30 years and the odd number of years is due to negotiations between the delinquent borrower and the lender after loan origination to extend the period over which the loan shall be paid. As for the change in mortgage rates, the average CMR1 is around -0.8926, with a range of around -4.1700 to 0.2100. The mean CMR2 is around -0.7777, with a range of -4.0600 to 0.3500. The mean of PREMR is 2.5835.

72.99% of the sample cases are leasehold properties and the remainder are of freehold tenure. Property type (TYPE) is dominated by high-rise properties. 546 (86.26%) of the mortgages were backed by either condominium housing or apartments. Terraces, semi-detached housing or detached housing backed the remaining 87 (13.74%) mortgages. The average land area (LAREA) of the low-rise properties is 2,436 sq ft and it ranges from 1,317 sq ft to 8,256 sq ft depending on whether they are terraces, semi-detached or detached housing, in ascending order of the level of land area. The floor levels (FLOOR), which the high-rise properties are located, range from 1st to 33rd storey with the average level of 6.81. The built-up area (BUAREA) of all the properties range from 150 sq ft for a one-room condominium to 4,639 sq ft for a detached housing. The mean BUAREA is 1516 sq ft.

Exhibit 3: Descriptive statistics of full sample

Variable	Mean	Std Deviation	Minimum	Maximum
Origination Date	19919595.6	1010654.37	1980320.00	19991202.0
Delinquency Data				
Delinquency Date1	20016058.8	8141.9823	19990201.0	20020826.0
Delinquency Date2	19998476.9	8400.4105	19990101.0	20011201.0
Duration Period1	148.2353	105.2518	60.0000	420.0000
Duration Period2	110.6897	115.3854	30.0000	480.0000
Mortgage Loan Specific Characteristics				
Loan Amount	364681.8910	161589.0000	30000.0000	1640000.0000
Valuation	670357.2890	295256.3300	147000.0000	3400000.0000
CPF Lumpsum	115545.4250	114597.7730	.0000	631000.0000
LVR	.5655	.1851	.0316	0.7831
PREMIUM	.0012	.0527	-.5000	.5227
CPFPRICE	.1726	.1468	.0000	.9221
MT	24.0774	6.2959	3.0000	33.0000
CMR1	-.8926	.5692	-4.1700	.2100
CMR2	-.7777	.5741	-4.0600	.3500
PREMR	2.5835	.2663	1.9200	2.9200
Property Specific Characteristics				
TENURE	.7299	.4444	.0000	1.0000
TYPE	.8626	.3446	.0000	1.0000
LAREA	2436.3158	983.5124	1317.0000	8256.0000
FLOOR	6.8163	5.4965	1.0000	35.0000
BUAREA	1515.8495	577.3723	1500.0000	4639.0000
PPRICE	670896.0810	291398.7920	160000.0000	3400000.0000
CRENTS1	-.1538	.1424	-.4030	-.0042
CRENTS2	-.1431	.1429	-.3999	.1734
Borrower Specific Characteristics				
Monthly Instalment	2097.9450	1293.6485	143.0000	18000.0000
PINCRATIO	.2699	.1584	.0095	0.6310
BORROWER	2.0679	.5426	1.0000	5.0000
AGE	36.3924	7.0931	20.1202	62.0427
PURPOSE	.0442	.2058	.0000	1.0000
INCOME	104440.0020	62502.4653	16900.0000	747309.0000
YRSEMP	9.1232	7.6898	.0833	37.0000
Environmental Characteristics				
CUNEMP1	.7305	.6530	-.3953	2.4286
CUNEMP2	.5895	.5947	-.3231	1.750
CSTI1	-.0636	.2334	-.3882	.7136
CSTI2	.0001	.2522	-.3690	1.3031
CGDP1	.2256	.2301	.0235	2.141
CGDP2	.1874	.2192	-.0366	2.0504
CRPPI1	-.0321	.2793	-.3633	1.6066
CRPPI2	-.0215	.2712	-.3618	1.6450

The sample of 633 residential mortgages is backed by properties with purchase price (PPRICE) of between \$160,000 to \$3,400,000. The average PPRICE is \$670,896. As for the change in rents (CRENTS), the mean values for CRENTS2 is around -0.1431 with a range of 1.7340 to -0.3999. CRENTS1 has a higher average of around -0.1538, but a narrower range of -0.0042 to -0.4030.

Monthly mortgage instalments payable has an average of \$2097.94. The corresponding PINRATIO ranges from 0.0095 to 3.0508 with an average of 0.2699. BORROWER varies from 1 to 5 with a mean of 2.0679. PURPOSE is dominated by that of owner-occupation at 95.57% or 605 cases while the remainder is purchased for investment. The mean of INCOME is at \$104,440 with a range of \$16,900 to \$747,309. The average YRSEMP is 9.12 years.

In the periods under study, the change in unemployment rate (CUNEMP) has generally been positive. However, average CUNEMP1 is higher at 0.7305 than average CUNEMP2 of 0.5895, due to the deterioration in employment situations in Singapore in 2002. Generally, unemployment rates have been increasing due to the economic crisis in the region. However, due to the relatively large standard deviations, the median can be a more precise measure of central tendency.

The average of CSTI2 is relatively low at 0.0001. In contrast, the mean of CSTI1 is negative at -0.0636. In both definitions of delinquency, the relatively large standard deviations when compared with the corresponding mean values suggests that there have been reasonably large fluctuations in the STI over the period from the origination dates of the loans to the delinquency dates or the censor dates. Similarly in the changes in Gross Domestic Product (CGDP), the average of CGDP1 is relatively larger than CGDP2.

The averages of the changes in the residential property price index (CRPPI) are consistently negative, suggesting a fall in RPPI over the study periods. The ranges of both definitions of delinquency are also similar.

RESEARCH METHODOLOGY

The probability of delinquency is examined by firstly assigning the dependent binary y_i to be either 0, which indicates a non-delinquent loan, or 1, indicating a delinquent loan. The probability of delinquency is then modelled using a vector of independent variables, denoted as x_i . A general specification is that the probability of observing 1 for y_i is:

$$\Pr (y_i = 1) = F (\beta x_i) \quad \text{for } i = 1, 2, \dots, N$$

where: F is an appropriate distribution function
 x is a vector of covariate values and
 β is a vector of model parameters.

We shall then specify two specifications for F, vis-à-vis the Logit and Probit models by specifying $F = \Lambda$ and $F = \Phi$ respectively. The cumulative distribution curve of both the Logit and Probit models is an S shape, bounded in the interval (0, 1) and such that $E(Y_i) \rightarrow 0$ when $X_i \rightarrow -\infty$ and $E(Y_i) \rightarrow 1$ when $X_i \rightarrow \infty$.

The Logit model could be expressed as:

$$\Lambda(x) = \frac{\exp(\beta'x)}{1 + \exp(\beta'x)} \quad (1)$$

The Probit model could be expressed as:

$$\Phi(x) = \int_{-\infty}^{\beta'x} (2\pi)^{-1/2} \exp\left(-\frac{1}{2}t^2\right) dt \quad (2)$$

It is well accepted that the logit and probit models can be estimated by maximizing the likelihood function, where

$$L = \prod [F(\beta'x_i)]^{y_i} [1 - F(\beta'x_i)]^{1-y_i} \quad (3)$$

The rationale for the use of both the Logit and Probit models is to account for the relatively small sample size used in this study. Although the models have similar cumulative distribution curves, the underlying assumptions of their distribution are, nevertheless, different. The robustness of the inferences drawn can be endorsed if both models yield similar results in both signs and significance.

EMPIRICAL RESULTS

The analysis is conducted for the two different definitions of delinquency and periods of study. In each analysis, the full set of variables is included in a run without delineation among the categories of determinants. The rationale for the categorization is to facilitate our discussion on their relative significance. The notations used are presented in Exhibit 4. Only the results of the Logit model are presented here as the findings of the Logit and Probit models yield similar signs and significance for the determinants. The summary results of the Logit analysis are presented in Exhibit 5, while the full results are found in Exhibit 6.

Exhibit 4: Legend of notations used

Notations Used	Meaning
Analysis 1	Analysis using delinquent cases that are in legal proceedings in the period of January 1999-July 2002
Analysis 2	Analysis using 4-month delinquency cases in the period of January 1999-December 2001
LVR	Loan-to-Value Ratio
PREMIUM	Price Premium
CPFPRICE	CPF-to-Price Ratio
MT	Mortgage Term
CMR	Change in Mortgage Rate
PREMR	Premium of Mortgage Rate over Investment Rate
TENURE	Tenure where 99-year Leasehold = 1
TYPE	Type of Property where Low-rise = 0
LAREA	Land Area
FLOOR	Floor Level
BUAREA	Built-up Area
PPRICE	Purchase Price
CRENTS	Change in Rents
OCRENTS	Orthogonalized Change in Rents
PINCRATIO	Payment-to-Income ratio
BORROWER	Number of Borrowers
AGE	Age of Youngest Borrower
PURPOSE	Purpose of Purchase where Owner-occupation = 0
INCOME	Total Annual Income of Borrowers
YRSEMP	Number of years in current employment
CUNEMP	Change in Unemployment Rate
CSTI	Change in STI
CGDP	Change in GDP
CRPPI	Change in RPPI
OCRPPI	Orthogonalized Change in RPPI

Tests for multicollinearity⁷ and heteroscedasticity⁸ have been undertaken to ensure the robustness of the model. Generally, it is found to be not influential on our findings.

⁷ We attempted to detect problems of multicollinearity with a correlation analysis of the relevant variables. It is found that the correlation coefficients are relatively low, ranging from 0.014 to 0.482. To further verify the effects of multicollinearity, we orthogonalize the more highly correlated variables. The results show that only one variable, the CUNEMP, is affected. The direction of influence changed from negative to positive but it became insignificant. The change is beneficial to us as the positive sign is what we had postulated in theoretical predictions.

⁸ Heteroscedasticity is tested with a scattergram of estimated squared residuals against a regressor. The plot found that the residuals are randomly distributed. An appeal to the Glejser method also showed no signs of heteroscedasticity. Furthermore, it has been argued that since the logit and probit models have flexible functional forms in the independent variables, the problem is less severe (Wooldridge, 2003).

Exhibit 5: Summary results of independent variables

Variable	Expected Sign	Actual Sign	
		Analysis 1	Analysis 2
Mortgage Loan Specific Characteristics			
LVR	+	+	-
PREMIUM	+	-	-
CPFPRICE	-	-	- *
MT	-	-	-
CMR	+	+ *	+ *
PREMR	-	+ *	+
Property Specific Characteristics			
TENURE	-	+	+
TYPE	+	N.A.	-
LAREA	+	N.A.	-
FLOOR	+	+	-
BUAREA	+	+	+
PPRICE	+	+	-
CRENTS	-	- *	- *
Borrower Specific Characteristics			
PINCRATIO	+	+ *	+
BORROWER	-	+ *	+
AGE	-	+	-
PURPOSE	+	N.A.	-
INCOME	-	-	+
YRSEMP	-	+	+
Environmental Characteristics			
CUNEMP	+	- *	- *
CSTI	+	+ *	+ *
CGDP	-	-	+
CRPPI	-	-	- *
Log Likelihood Function		-43.0619	-76.8299
McFadden R2		0.5328	0.3474

*Significant at the 5% level (refer to Exhibit 4 for the legend of notations used in this exhibit)

Exhibit 6: Full results of analysis 1 & analysis 2

Determinant	Coefficient	Standard Error	t-statistic	p-value
Analysis 1				
Constant	-18.53990827	5.8893360	-3.148	.0016
LVR	.4904927454	2.7135484	.181	.8566
PREMIUM	-6.365766899	5.9931157	-1.062	.2882
CPFPRICE	-3.180446440	2.4500712	-1.298	.1943
MT	-.7205013190E-01	.53981624E-01	-1.335	.1820
CMR1	3.664767815	1.1844269	3.094	.0020
PREMR	4.164081249	1.5452765	2.695	.0070
TENURE	.5913828123	1.1978689	.494	.6215
FLOOR	.1153190891E-01	.11060360E-01	1.043	.2971
BUAREA	.2180506303E-02	.14032399E-02	1.554	.1202
PPRICE	.5180490095E-06	.22504714E-05	.230	.8179
CRENTS1	-24.56607358	4.9955239	-4.918	.0000
PINCRATI	2.306309337	1.0140138	2.274	.0229
BORROWER	1.561357585	.47904694	3.259	.0011
AGE	.4983431266E-04	.11951814E-02	.042	.9667
INCOME	-.6676424186E-05	.66710920E-05	-1.001	.3169
YRSEMP	.1785281139E-01	.36416380E-01	.490	.6240
CUNEMP1	-4.365533927	1.0567677	-4.131	.0000
CSTI1	6.180859080	2.0699531	2.986	.0028
CGDP1	-4.113392575	3.5498569	-.116	.9078
CRPPI1	-2.567199895	2.7242548	-.942	.3460
Analysis 2				
Constant	101.0111405	113.22192	.892	.3723
LVR	-2.104764459	1.9169293	-1.098	.2722
PREMIUM	-2.794457767	3.7476131	-.746	.4559
CPFPRICE	-5.042772314	2.0797756	-2.425	.0153
MT	-.4397856273E-01	.38324854E-01	-1.148	.2512
CMR2	6.118846984	1.6580026	3.690	.0002
PREMR	1.053254547	.96876104	1.087	.2769
TENURE	.2356916930	.83774633	.281	.7784
TYPE	-175.2333601	198.68778	-.882	.3778
LAREA	-.7429836355E-01	.85402941E-01	-.870	.3843
FLOOR	-.1895394925E-01	.26981238E-01	-.702	.4824
BUAREA	.3648345704E-03	.10228569E-02	.357	.7213
PPRICE	-.2354624823E-05	.21781536E-05	-1.081	.2797
CRENTS2	-10.27235797	3.9770287	-2.583	.0098
PINCRATI	.8820291494	1.0256790	.860	.3898
BORROWER	.4703444034	.39619746	1.187	.2352
AGE	-.1465399709E-03	.10016021E-02	-.146	.8837
PURPOSE	-.3049483151	1.2532968	-.243	.8078
INCOME	.3562570646E-05	.51160757E-05	.696	.4862
YRSEMP	.1537458683E-01	.28067274E-01	.548	.5838
CUNEMP2	-4.635232439	1.0909531	-4.249	.0000
CSTI2	10.52819523	2.7998341	3.760	.0002
CGDP2	3.099953295	3.3268370	.932	.3514
CRPPI2	-13.53561943	5.1634379	-2.621	.0088

(Refer to Exhibit 4 for the legend of notations used in this exhibit)

Mortgage loan specific characteristics

Contrary to findings by Von Furstenberg and Green (1974) and Campbell and Dietrich (1983), our study found that LVR is insignificant in the analyses. This is probably in line with the argument by Campbell and Dietrich (1983) that the LVR is less influential for delinquency than for default. In addition, consistent with both previous studies, Analysis 2 found a negative relationship. However, Analysis 1 produced a positive relationship. This is in accordance to our expectation. There is thus inconclusive evidence on the signs of influence of the LVR.

Even though the PREMIUM is found to be insignificant, the difference in signs between the results and that expected leads to interesting implications. The results seem to indicate that as the borrower pays a higher premium over the valuation, the probability of delinquency will be lower. A possible explanation is that those who paid a higher premium are owner-occupiers, whom have a lower probability of delinquency. As the property is for long-term residential use, owner-occupiers are more willing to pay a higher premium for housing that they prefer. Their penchant for the housing will further motivate them to avoid delinquency. CPFPRICE is significant in explaining delinquency only in Analysis 2. The negative relationship is as expected. The expected direction of influence of MT is consistent with the findings of both analyses. However, none of the analyses are significant at the 5% level.

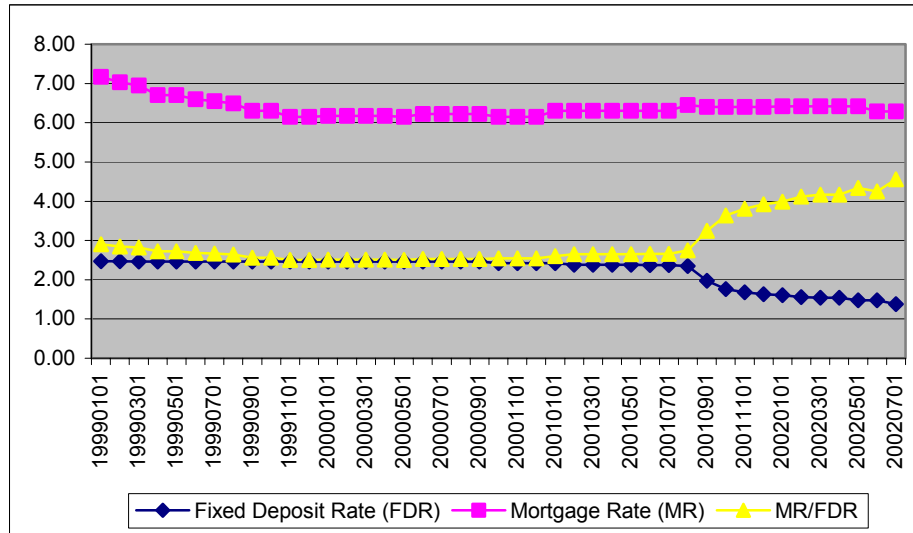
The coefficients on CMR in both analyses are significant and positive as expected. This is consistent with the previous studies on default rates by Cunningham and Capone (1990), Foster and Van Order (1984) and Vandell and Thibodeau (1985). This indicates that the determinant has a significant impact on both delinquency and default rates. As the financial burden of the mortgage is increased by a rising mortgage rate, the borrower is more likely to become delinquent and subsequently leading to default/ foreclosure.

PREMR is shown to exert a positive impact on delinquency but is significant only in Analysis 1. This is contradictory to what we had expected. A possible explanation is that the inverse influence of an increase in the investment returns is dominated by the positive influence of a decrease in mortgage rate of the CMR. To verify this, an analysis of the ratio of the mortgage rate over the investment return rate is carried out. From Exhibit 7, it can be observed that mortgage rate is more influential in affecting the ratio before September 1999 where it is showing a downward trend. On the other hand, the fixed deposit rates exhibit a declining trend after August 2001 and is influential in affecting the ratio in a significant manner. Thus borrowers seem to be more sensitive to changes in the mortgage rate than to that of the proxy for investment return rate.

Property specific characteristics

FLOOR and PRICE produced mixed results although both are insignificant at the 5% level. For both determinants, Analysis 1 yielded a positive relationship, which is consistent with theoretical predictions, while Analysis 2 showed a negative influence. As both determinants relate to how expensive the mortgaged properties are, the results indicate that properties that are more expensive have a higher probability of going into legal proceedings but a lower probability of being 4-month delinquent.

Exhibit 7: Mortgage rate, investment return rate and ratio of mortgage rate over investment return rate (January 1999 – July 2002)



Delinquency rate is found to be consistently lower when BUAREA is smaller. This is in line with the above argument, since properties with larger BUAREA are more expensive than smaller ones. However, BUAREA is also found to be insignificant.

The negative significant influence of CRENTS indicates that when the rent of the property falls, the borrower will be more prone to miss his mortgage payments. This effect is consistent across all analyses. However, the high level of significance is somewhat surprising, as 95.58% of our samples are owner-occupiers instead of for investors. Hence, a low impact on delinquency is expected. A possible explanation is that the rents could represent a proxy for the cost of delinquency. This is due to the threat of default and foreclosure where the borrower may lose his property and consequently have to rent an alternative accommodation. Another argument is that a greater proportion of borrowers have actually rented out their property than what they were willing to admit.

Borrower specific characteristics

The expectation of a positive influence of PINCRATIO was substantiated by the results although it is not found to be significant. It was also expected that as BORROWER increased, the possibility of delinquency would be lower. However, our models discovered a positive relationship. Although significance was limited to only Analysis 1, the positive sign, would imply that a greater number of borrowers lead to higher chances of delinquency. Further analyses are conducted to examine whether the results are caused by a higher delinquency risks among loans with high number of borrowers. This is done by classifying the loans into groups of less than or equal to 1 borrower and subsequently, also into groups of less than or equal to 2 borrowers, using dummy variables. However, the positive relationship is still observed. A possible reason is that in an attempt by the lender to reduce delinquency risk, it stipulates a higher number of borrowers for more risky loans. Despite this, the higher-risk loans are still prone to delinquency. However, having more than one borrower may still mitigate delinquency risk to a certain extent.

Another check is undertaken to determine whether the total borrowers' income is higher among loans with smaller number of borrowers. It is found that the average income for loans with 2 or less borrowers is significantly higher than for loans with more than 2 borrowers at the 1% level (see Exhibit 8). Consequently, the effect of lower incomes among loans with more than 2 borrowers may be responsible for the higher rate of delinquency, rather than the effect of the higher number of borrowers itself.

Exhibit 8: Independent t-test results for total income of borrowers according to the number of borrowers

Number of Borrowers	Mean Values	Equal Variances assumed		Equal Variances not assumed	
		t-statistic	Sig. (2-tailed)	t-statistic	Sig. (2-tailed)
<= 1	97345.5400	.836	.403	.641	.524
> 1	105048.4464				
<= 2	124602.6250	2.925	.004**	3.187	.002**
> 2	101852.2857				

** Significant at 1% level

The results show that INCOME is not significant and the signs of influence are not consistent across the two analyses. This is interesting in two ways. Firstly, the insignificance of both PINCRATIO and INCOME seem to suggest that financial institution's reliance on ability-to-pay measures to assess credit risks is erroneous. This is contrary to the finding by Herzog and Earley (1970), von Furstenberg and Green (1974), Morton (1975) and Campbell and Dietrich (1983) that INCOME is influential in affecting delinquency rate. Secondly, the mixed signs of influence suggest that lending to borrowers with a higher total income may not necessarily

reduce the risks of delinquency. In fact, Canner, Gabriel and Woolley (1991) found an inverse relationship between the liquid assets of the borrowers and delinquency. Delinquency rate seem to be higher when the number of years in current employment (YRSEMP) is higher, although it is found to be insignificant.

Environmental characteristics

CUNEMP is a significant factor although the negative influence is opposite of that expected. This finding is interesting but is not without precedent. Cunningham and Capone (1990) found a negative relationship between the regional unemployment rate and the incidence of prepayment and default. This is contrary to most studies including those by Lea and Zorn (1986), Case and Shiller (1996) and Capozza et al. (1997), who found a positive relationship.

A possible explanation is the effect of the economic cycle. In the period of analysis from January 1999-July 2002, Singapore was going through a recession that started in late 1997. This has perhaps adversely affected borrowers so much that even when the unemployment rate falls, borrowers are only slightly better off. The greater certainty of income due to such an improvement is seen as only temporary. Another reason is due to the effects of the model. The test for multicollinearity found CUNEMP to be correlated with CRENTS and CRPPI. Removing the effects of the correlation through orthogonalization found the sign of CUNEMP becoming positive although insignificant.

CSTI is found to be significant in both the analyses and the sign is positive as expected. This implies that when CSTI increases, more attractive investments become available and draw funds away from mortgage payments.

The results from CGDP are not coherent. The expected negative sign is only present in Analysis 1. This suggests that when CGDP and by default the income of the borrowers increases, borrowers will be less prone to delinquency. On the other hand, Analysis 2 showed a positive relationship. This suggests that when CGDP and borrowers' income increase, the risk of delinquency will correspondingly increase. This ambiguous finding was initially thought to be due to possible correlation with CSTI. Another set of analyses was thus produced with CSTI removed. However, the signs and significance of influence remained unchanged. Even leaving out other variables that may correlate with CGDP continues this result.

The coefficient of the CRPPI is found to be consistently negative, in line with theoretical prediction. Thus, capital appreciation is found to result in a lower rate of delinquency. The high level of significance found for Analysis 2 is rather interesting. As with CRENTS, the CRPPI is expected to have a low influence on owner-occupiers. Similar argument that more borrowers in our sample are actually

borrower-investors can be put forth. Another possible explanation is that capital appreciation is usually accompanied by good performance of the economy in general and hence rises in income.

Implications of results

The results suggest that macroeconomic and several mortgage loan factors are more influential in determining delinquency than property and borrower specific factors. This has significant implications for the mortgage lending industry. Traditionally, lenders have focused their lending criteria on borrower specific characteristics. Even within the mortgage loan specific characteristics, the equity measure of LVR is found to be insignificant. The focus should instead be on the extent to which the lender will change the mortgage rates during the life of the mortgage and also the disparity between the mortgage rate and potential investment returns. Future macroeconomic situations and change in rentals also have a major impact on delinquency. However, these systematic risks are more difficult to predict and cannot be controlled by lenders. Thus, lenders and investors should be aware that delinquency risk is dependent upon the occurrence of factors that may not be known at the time of origination or investing.

The main limitation of this study is the limited period of study for the delinquent cases. Further analysis using a larger sample size and a longer study period may be required to further verify the results obtained in this study.

CONCLUSION

This study has provided several critical implications for lenders and investors in the mortgage and MBS market respectively. With respect to the significant determinants, this study seems to suggest that mortgage delinquency risks are largely dependent on uncontrollable factors. This implies that lenders' abilities to reduce the overall risks of delinquency in their mortgage portfolio are limited. It also indicates that issuers of MBS are unable to provide an "optimal" package of mortgages to minimize the risks of delinquency.

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