Mortgage Prepayment and Default Behavior with Embedded Forward Contract Risks in China's Housing Market

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Abstract

Most condominiums in China are sold forward on a pre-sale market, where purchasers and developers transact on an underlying property that is not yet completed. During the pre-sale period home buyers face a significant forward contract risk. However, home buyers can borrow mortgages from banks so that they can effectively share the forward contract risk with banks. This explains the phenomenon of irregularly high early-stage default and prepayment rates observed in residential mortgage lending in China, where there are few, if any, financial incentives for mortgage borrowers to exercise either put or call options. Mortgages collateralized by forward housing assets are riskier than are those with underlying assets traded on the spot market. However, currently Chinese mortgage banks charge the same rate to all mortgage borrowers. This inefficiency in risk sharing between mortgage borrowers' groups in the forward and spot housing markets leads to mispricing in secondary mortgage sales and mortgage-backed security trading.

Keywords: mortgage, prepayment, default, credit risk, forward contract, pre-sale

JEL Classification: G12, G14, G21, H31

Introduction

The residential mortgage market in China has grown rapidly since 1998, with an average annual growth rate of roughly 100%. By the end of the first quarter of 2005 the outstanding balance of residential mortgages reached 1.7 trillion RMB Yuan (Fig. 1), approximately USD 207 billion.[1] There are two highly distinctive features of the Chinese mortgage market: First, the People's Bank of China (the central bank in China) sets the mortgage rate, which applies to all borrowers.[2] Second, beyond the standard "spot" market for existing housing transactions, there is an active forward real estate market in the sense that the developer can sell a housing unit before its completion, sometimes even before construction begins.

A pre-sale practice that distinguishes China's housing market from other housing markets is the timing of the fund allocated to developers. In many housing markets around the world, the funds (which typically consist of a certain percentage of the purchasing price of the property) are put into an escrow account and allocated to the developer gradually according to the progress made in building the development. In China, however, at least before 2007, funds are transferred to the project developer all at once. At the closing time of such a pre-sale, the purchaser can either pay the pre-sale price in full or finance a certain amount (usually 80% of the purchasing price during the period of 1998 to 2003) from a bank. As a result, during the presale[3] period home buyers face a significant forward contract risk. However, since home buyers in China are allowed to borrow a standard mortgage from a bank to finance such a pre-sale unit, home buyers in the pre-sale housing market share the forward contract risk with banks.

This explains the phenomenon of irregularly high early-stage default and prepayment

[1] As of March 2007 the exchange rate of Chinese Yuan (CNY) is one U.S. dollar=7.74 CNY.
[2] There is a long history of not using risk-based interest rates in China or other central-planning economies. It is also a tradition that in those countries a unified product or service is provided to all consumers.
[3] We use the terms 'forward market' and 'pre-sell market' interchangeably.

rates observed in residential mortgage lending in China, where there are few if any financial incentives for mortgage borrowers to exercise either put or call options. A consumer (home buyer) in China's forward housing market will choose to default her mortgage contract if the developer defaults the forward housing contract. If the forward housing unit is delivered, the consumer may choose to prepay the loan depending on her liquidity constraints and returns through alternative investment channels. Because of the embedded risk of developer default, mortgages collateralized on pre-sold properties are more risky than their counterparts on the spot market are.

This paper studies the competing risks of mortgage prepayment and default with embedded forward contract risk of developer's default. The economic model is based upon the Cox proportional hazard model of mortgage termination (Cox 1972, 1975). The empirical analysis is based upon a rich set of mortgage-lending data from a leading mortgage lender in China. The loan history dataset contains not only mortgage loan characteristics, but also information about borrowers and developers. The unique dataset allows us to study mortgage borrowers' prepayment and default behavior with embedded forward contract risks. The finding of this study will provide valuable insights into emerging housing and mortgage markets in China as well as those in other transitional economies. The remainder of the paper is organized as follows. Section "The Mortgage and Housing Markets in China" describes the Chinese mortgage market in detail, including both the single mortgage rate constraint and the forward market for new units. Section "The Data" describes the data used in this study. Section "The Empirical Model and Estimation Methodology" lays out the empirical methodology. Section "Empirical Results" presents a discussion of the empirical results. A brief conclusion follows.

The Mortgage and Housing Markets in China

The long history of the real estate and consumer loan markets in China was transformed abruptly in 1949, when China adapted the central planning system. For a long period of time, under the central planning regime, housing in China had been treated as a social welfare product administrated and delivered by state agencies (e.g., state-owned enterprises—SOEs—and housing bureaus) for its people. Under such a welfare-oriented system, the private housing market and the residential mortgage system were extinguished. The mission of Chinese banks was to act as government-directed funding sources for SOEs.

Since the early 1980s, China has gradually restructured its housing system. Market mechanisms, with the objectives of eliminating state housing allocations, promoting the privatization of public housing, and encouraging private housing development, were introduced in stages to replace the welfare housing system. Although China's first modern residential mortgage loan was issued in 1986 by the China Construction Bank (CCB), the mortgage market did not play an important role in the Chinese residential housing market for another decade. By the end of 1997, the total outstanding mortgage balance in the People's Republic of China was only approximately 19 billion RMB Yuan (USD 2.35 billion). In 1998, the People's Bank of China, which functions as the central bank of China, and the State Council of China announced several administrative laws to speed up housing construction and intensify urban housing reform. The State Council announced that, among these measures, it would no longer allow SOEs to allocate welfare housing to their employees after December 31, 1999. At that point residential mortgage lending began to accelerate. By the end of 2005 the outstanding balance of residential mortgages exceeded two trillion RMB Yuan (USD 198 billion), almost 89 times the1997 balance. Residential mortgages play an increasingly important role in Chinese banks' lending activities. The outstanding mortgage balance constitutes more than 12% of total loans made by

financial institutions in the same period in 2005, compared with less than 0.4% in 1997.

Although mortgage lending currently constitutes about 85% of total consumer lending, the ratio of mortgage loans to total loans was 7.5% in 2003, which is lower than it is in most developed countries (e.g., the ratio of mortgages to total loans is 39% in the U.S. and 59% in the U.K.), and even lower than in other countries in the Asia-Pacific region (Fig. 2). Therefore there is much room for continuing growth in China's mortgage lending practice.

For details on the background of mortgage lending in China, please refer to Deng et al. (2005).

Risk Management in Chinese Mortgage Banking

Lending activities in China's residential mortgage markets are dominated by four major state-owned banks. They account for more than 90% of the total outstanding mortgage balance. Of these four banks, Industrial and Commercial Bank of China (ICBC) and China Construction Bank (CCB) are the two leading mortgage lenders, representing about 70% of total outstanding mortgage loans.

Chinese banks adopted a five-category system to manage the default risks of mortgage portfolios in 2003. The five default-risk categories are *Prime, Subprime, Irregular, Distress,* and *Default.* Before approval of a loan, a bank investigates the credit worthiness of each applicant. The bank will approve a mortgage to an applicant according to several borrower characteristics such as family income, occupation, etc. Therefore there are only two pre-lending classes: *Prime* and *Subprime*. The bank watches the borrowers' payment behaviors carefully and makes frequent adjustments to the borrowers' risk level if it sees any warning signals. In particular, if the number of delinquencies is between three and six, the mortgage borrower's risk level

becomes *Irregular*; if the number of delinquencies is above six then the borrower's risk level becomes *Distress*. The last category in the five category risk level is *Default*. The headquarters of a mortgage lending bank also actively monitors its branches and subsidiaries. An early warning is given to branches with a 1%-to-3% delinquency rate in their mortgage loan portfolios; the headquarters requires a reorganization of mortgage operations at branches whose delinquency rate falls between 3% and 5%; the mortgage lending license would be revoked if a branch has a greater-than-5% delinquency rate.

The Pre-Sell Practice in China's Housing Market

Just as consumers can purchase financial instruments, they can also buy real estate either on the spot market or on the forward market (pre-sales). On the spot market, consumers and developers transact on existing housing units-housing stock; while on the forward market, consumers and developers agree on the price at the date of sale but the underlying property, which is not yet completed, is transferred to the buyer only at a certain later time, usually at the date of completion. Because the unit is sold well before completion and occupation, the forward contract is often called a presale or pre-construction transaction.

Mainland China adopted the pre-sale system in 1994, after the Chinese Ministry of Construction established "Urban Housing Pre-Sale Management Approaches." Now a majority of residential housing units in urban China are transacted on the forward or pre-sale market. Developers usually sell condominium units well before completion, usually one to 3 years before,[4] in order to hedge development risks and acquire additional funding.

Pre-selling exists not only in China, but it is also a popular practice in most emerging

[4] The pre-sale period used to be around four years, but has now decreased to one to two years.

Asian markets and in some developed countries. For example, Ong (1997, 1999) studied the pre-sale market in Singapore; Chang and Ward (1993) studied the pre-sale market in Taiwan; and Chau et al. (2003, 2007), Yiu et al. (2005) and Wong et al. (2006) studied the Hong Kong market. In the United States, pre-selling of buildings and resort condominiums (in Miami and Hawaii, for example) has become a standard process, and virtually every condominium is presold today.[5] The procedures involved in forward sales vary from market to market, and sometimes from developer to developer, along the following dimensions: length of pre-sale period, size of down-payment/deposit, payment schedule, refund policy in case of developer default, and eligibility for mortgage loan and mortgage rate.

The most important feature that distinguishes pre-sale practices in China's housing market from those in other markets is the timing of the fund allocated to developers. In most markets, such funds (which typically consist of a certain percentage of the purchasing price of the pre-sale properties) are put into an escrow account and allocated to the developer gradually according to the progress made in building the development. In China's housing market, however, at least before 2007, funds are transferred to the project developer all at once. At the closing time of such a pre-sale, the purchaser can either pay the pre-sale price in full or finance a certain amount (usually 80% of the purchasing price during the period of 1998 to 2003) from a bank. This special design in the pre-sale system is again due to China's housing reform (See Yi and Huang 2007). Starting in the early 1990s, as the middle-income class has expanded, its pent-up demand for housing has been unleashed; furthermore, employees could no longer obtain welfare housing from SOEs after December, 1999. However, the private housing supply was insufficient and banks were reluctant to make construction loans to new developers. Despite the fact that the pre-sale practice significantly lowers the entering threshold for the real estate

[5] A sample pre-sale contract can be found at the Miami real estate Web site, http://www.miamirealestate-trends.com

industry in China, thus encouraging more and more private firms to become involved in residential housing development, there is a major flaw in its design. The lack of legislative protection for buyers and the lack of properly monitoring of a developer's use of funding gives some developers an opportunity to transfer the risk of development to banks and buyers.

The Data

Micro Mortgage Loan Data

The unique micro mortgage dataset collected by the largest residential mortgage lender in Beijing was first used by Deng et al. (2005). In this paper we enriched the dataset along several dimensions. We updated the mortgage loan data from October 2002 to the end of 2003. Furthermore, we extended the loan information to include property information and developer characteristics. This second extension is crucial because those variables enable us to merge borrowers' characteristics associated with loans with the collateral information from developers in Beijing. The loan dataset includes 103,462 individual mortgage loans issued between 1998 and 2003. The mortgages are 5-year, 10-year, 15-year, and 20-yearadjustable-rate loans with full amortization. For each loan, the available information includes the year and month of origination and termination (if it has been closed), indicators of prepayment or default, the original loan amount, the down payment rate, the initial loan-to-value ratio, maturity, the remaining term, the repayment method, the mortgage contract rate, the purchase price of the property, the size of the house, the location of the property, the sale type, the appraisal value of the property at the time of sale, the unit price, etc. Other borrower characteristics include the borrower's name, education, gender, monthly income, occupation and position, number of dependents in the household and spousal income. The dataset also includes geographical information about the property and its

developer. This microloan data is well suited for the study of mortgage default and prepayment since Beijing is the capital city of China and the real estate sector is steadily increasing without a speculative bubble. Among the 103,462 mortgage loans, 1,384 loans were defaulted and 10,055 loans were fully prepaid during the sampling period, and 92,023 loans were censored at the end of year 2003. This data is best suited for survival analysis because the data avoid the truncation and censoring problems. The sample started in 1998, which is the first year the bank issued mortgage loans. There is no left truncation problem such as most research suffers from in the sample selection process. The data collection cutoff date is December 31, 2003. Therefore right censoring is non-informative.[6]

Tables 1, 2, 3, 4 and 5 provide the descriptive statistics on the mortgage loans. Among the 103,462 residential mortgage loans that originated in Beijing, more than74% are based on forward contracts. Among 1,384 defaulted loans and 10,055prepaid loans, more than 90% are from the forward market. Borrowers' behavior in default and prepayment vary by such loan characteristics as LTV and original loan amount, and by borrower's income, occupation, and other household characteristics. In addition, borrowers' behavior in default and prepayment vary by such developer characteristics as type, size, quality, history, etc. For example, about 45% of defaulted loans originated on properties built or to be built by joint developers with partners in Hong Kong, Macau, or Taiwan (HMT hereafter); while only 5% are from joint developers with partners in foreign countries. Among all prepaid mortgages, 47% are based on properties built or to be built by limited liability companies, while only 2.5% are done by joint ventures with HMT. Among the 103,462 mortgages, more than 63% of the loans originated on a property that is the

[6] An alternative sampling method, namely stratified sampling, can be used for a large dataset. To correct for possible sample selection bias, a weighting scheme that is assumed to be independent of error distribution can be used in the maximum likelihood estimation. Specifically, the weight addresses the stratified choice-based sampling of mortgages across loan status cells. The weight is commonly defined as the inverse of the probability that the loan is being selected from a cell in which it was sampled.

first project undertaken by its developer. Only 34% are by done by developers who have built more than one project in the past. Detailed descriptions can be found in Tables 1, 2, 3, 4 and 5.

Data on Real Estate Developers in Beijing

Real estate development was a highly regulated industry in China before 1992. With the privatization of state-owned housing and the fast growth of mortgage lending, real estate developers in China began to flourish. There were more than four thousand active real estate developers in Beijing as of 2005. Before 1992 there were only 37 state-owned real estate developers there. We obtained a dataset covering all developers in Beijing from the Beijing Urban Construction Development Office (BUCD thereafter). The BUCD is a government agency that regulates the real estate industry in Beijing. With growing concern about information disclosure pertaining to developer credit quality, the BUCD began to annually review all real estate developers in Beijing and publish the results on its official Website in 2004. This dataset includes 3,088 developers and 3,938 real estate development projects in total.

Among all developers, about 87% have only one property in Beijing; only 3% of the developers have four or more properties. The earliest developer in our sample, an SOE, started its real estate business in 1966. In 1992 the total number of developers was only 90, but the number quadrupled by 1997 to 335. Since then, the real estate development industry has experienced significant growth. By the end of 2003 the total number of developers was almost ten times the number in 1997.

For each developer in the sample, we have information on credit ratings from real estate administration offices and commercial banks, the type of the developer, the equity value of the firm at registration, the location of properties and the business address of the developer, the name

of the CEO, the total number of employees and the detailed number of certified professionals in management. We also have the issuance and expiration dates of the license as well as the starting date in the real estate business. A drawback of this data is that we did not observe periodic variation prior to 2004, while the mortgage data sample ends on January 1, 2004. Therefore, most of the developer characteristics are static.

The Empirical Model and Estimation Methodology

An Economic Model of Mortgage Prepayment and Default with Embedded Forward Contract Risks

A Simple Model for the Forward Housing Market

Figure 3 uses a simple timetable to illustrate the interrelationship between the home buyer (mortgage borrower), the developer, and the bank on the forward housing market in China. Following Liu (2007), we set up a three-period model in which agents make decisions only at discrete times such as $T = 0, 1, 2, 3$. $T = 1$ is the completion/delivery date of housing units. Home buyers (mortgage borrowers) can enter the housing market either at time $T = 0$ (on the spot market) or at $T = 1$ (on the forward market). Therefore the transaction date can be either at $T = 0$ or at $T = 1$. At the transaction date, the home buyer has to pay the developer the full purchase price on the housing unit and the home buyer is eligible to borrower an adjustable rate mortgage from the bank. The mortgage loan is usually less than or equal to 80% of the housing value. The mortgage matures at $T = 3$, but the borrower can terminate the loan at $T = 1$ or $T = 2$. Between time 0 and time 1, there is a pre-sale period, in which the developer sells housing units forward. At $T = 1$ of the forward market, there is some probability of developer's failure of delivery of the unit, which results in the default of the mortgage. In the case of default,

the bank takes the collateral residuals, which typically have very low recovery rates in China. If the housing unit is delivered in good quality, the home buyer (mortgage borrower) commences housing consumption. $T = 2$ is the option exercise date for a home buyer (mortgage borrower) who is consuming a housing service and pays monthly mortgage interest and principal. She would default if her housing equity is negative. She would prepay if the financing cost, i.e., the mortgage interest cost, exceeds the alternative investment return. The borrower may not optimally prepay the mortgage if she is either financially constrained due to a liquidity constraint or because she does not participate in stock market investment. Therefore if the home buyer (mortgage borrower) does not terminate the mortgage, at $T = 3$ she makes the last payment and obtains title to the house.

There are at least two main advantages to home buyers who lock into a pre-sale contract before the construction of a given property is completed. First, the housing price on the pre-sale market may be lower than that on the spot market (the developer is willing to cut the price for pre-sales, thus hedging its production risk). Second, there may be a richer menu of choices: location, size, view, etc. For developers, there are two benefits associated with a pre-sale contract. First, by locking in the selling price, the developer can hedge the project pipeline risk and share the risk with buyers. Uncertainty about future demand and inventory risk is significantly reduced. Second, the developer can access additional financing in addition to a construction loan, which is typically very difficult for private or new developers to procure.

Because of the popularity of the forward housing market and the practice involved in the risk-sharing mechanism adopted by home buyers (mortgage borrowers) in China, risks in the forward real estate market have been embedded in mortgage contract default risks, which complicates the valuation of the mortgage default and prepayment option in comparison with

those that occur in other countries.

Default Option with Embedded Forward Contract Risks

The option theory (Black and Scholes 1973; Merton 1973) has been widely applied to estimate the mortgage default and prepayment probability. Early examples include Findley and Capozza (1977) and Buser and Hendershott (1984), among others. Recent applications include more sophisticated modeling techniques (see, for example, Schwartz and Torous 1989; Stanton 1995; Deng et al. 2000). This method was however developed and first used in the developed mortgage market, in which spot housing contracts are predominant. It is necessary to understand the forward housing market and its option structures in order to apply the option theory to mortgage pricing where forward selling is active. With astonishing growth in the real estate market, many private developers have entered the residential housing market. There is increasing default risk among developers that fail to deliver housing. Many Chinese borrowers use a mortgage as a consumption insurance instrument with which to share the developer's credit risk with banks. In case the borrower does not get the desired home, i.e., the developer defaults or fails to satisfy the home buyer on the date of delivery, the borrower will default the loan. On the other hand, if the borrower receives a house of expected quality, she will not default, and will consider prepaying according to her liquidity constraint and other investment opportunities. If a borrower can earn a higher return from another investment portfolio (in the stock or bond market), and the borrower has cash on hand, she would rather not to prepay the mortgage. Although in reality the consumer has to evaluate the option value of waiting, the prepayment option in essence reflects the trade-off between the financing cost (mortgage rate) and the alternative return, as well as the borrower's liquidity constraint.

Default and Prepayment Option Analysis on the Forward Market

Due to the special features of pre-sales, mortgage options that originate on the forward market are different from those that originate on the spot market. Such mortgages face tremendous risks when developers fail to deliver properties on contracted delivery dates or fail to meet quality requirements specified in the pre-sale contracts. The two important institutional issues that permit such risk-sharing behavior are: (1) residential mortgages in China are non-recourse; and (2) there was no personal credit system in mainland China during the study, and banks do not share mortgage borrowers' information.[7] These features are especially common in transitional economies or developing countries.

Mortgage default can occur for two reasons during the pre-sale period. First, default can be caused by the developer's credit risks. These include market risk (via a channel of construction costs) and the idiosyncratic risk associated with the individual developers' characteristics. The second default risk comes from the borrower. An individual borrower can experience a negative income shock or other unplanned event (e.g., a major expenditure for medical care).

After the delivery date, mortgage options for pre-sale and non-presale transactions become identical. After the pre-sale period, a borrower can default or prepay on a mortgage. The mortgage default option can be regarded as a financial put option. If the current market value of the house, which serves as collateral on the mortgage debt, drops below the current value of the remaining mortgage balance, a borrower has an incentive to default. In a boom market, the default option is usually out of the money. Borrowers would be better off selling the house rather

[7] Since 2006, the China Banking Regulatory Commission has established a series of rules for building up the personal credit system and regulating pre-sale practices.

than defaulting if they have to move. On the other hand, the prepayment option is a real option (call) with the strike price updating every year (depending on the bank's ARM rate). This call option does not depend on the interest rate, but is closely related to the borrower's alternative investment opportunity set. One can think of mortgage debt as a consumption-smoothing instrument. In the current Chinese capital market, there are very few investment opportunities and very few borrowing vehicles. In mainland China the stock market is the major investment vehicle for Chinese citizens. Borrowers will therefore make prepayment decisions based on the cost of capital and stock market returns. They will prepay when the cost of capital (the mortgage rate), exceeds the investment return. Figures 4 and 5 show the mortgage rate dynamics and stock index return in China during the period of 1998–2005.

The Competing Risks Hazard Model of Prepayment and Default

Default and prepayment are options of borrowers embedded in any mortgage loan. Recent research on mortgage markets indicates that the behaviors involved in exercising those two options are distinct but not independent. For example, in exercising the default option the borrower gives up the option to prepay the loan in the future. We apply the Cox proportional hazard model (PHM) to assess the competing risks of mortgage termination by simultaneously modeling the prepayment risk and the default risk.

Since the early work of Dunn and McConnell (1981) and Green and Shoven (1986), researchers have modeled mortgage contracts in a contingent claims framework. The borrower's option to prepay a mortgage is an embedded call option at a strike price of par, while the default option is a put option at a strike price equal to the market value of the collateral property. The prepayment option gives a mortgage borrower the right to repay the mortgage balance when its

market value equals or exceeds par, i.e., when the market rate drops below the mortgage coupon rate. Exercise of the call option results from two primary motivations: (1) to refinance the existing debt at a lower rate of interest; or (2) to terminate the debt through the sale of the underlying asset—the house—due, for example, to relocation. Analogously to prepayment, mortgage default is a put option. If the current market value of a house, which serves as collateral for the mortgage debt, drops below the current value of the remaining mortgage balance, a borrower has an incentive to default. Therefore the default option gives the borrower the right to sell the house to the lender at a price equal to the value of the mortgage. In the absence of transaction costs, a rational borrower can maximize her welfare by exercising such options when they are in the money.

As discussed in the section above, the special features of China's mortgage contracts have to be taken into account when calculating the option values. In particular, the collateral for a pre-sale house has to be carefully modeled for the default option, while the prepayment option is different in an economy where there is essentially no interest risk. The prepayment option is at work, even though there is no interest risk, because mortgage borrowers then will decide when to exercise the option based on the trade-off between the borrowers' financing cost and alternative investment returns.

Furthermore, these two options compete against each other. Kau et al. (1992), Kau and Keenan (1995) have discussed the theoretical relationships among the options. Schwartz and Torous (1993) is among the first studies to demonstrate the empirical importance of such options.

The desired model outputs are explanatory variables affecting the conditional probabilities of mortgage default or prepayment. The PHM model estimates the effects of these

variables on the time to default. In particular, we estimate the probability that a mortgage with certain characteristics will be terminated in a given period where there has been no default or prepayment experience up until that period.

Following Deng et al. (2000), this paper simultaneously estimates the default risk and prepayment risk in the presence of forward markets. The joint survival function is given in the following form:

$$S\left(t_d, t_p \middle| H, R, X_C, X_B, Z, \varepsilon_d, \varepsilon_p\right) = \Pr\left\{T_d > t_d, T_p > t_p \middle| H, R, X_C, X_B, Z, \varepsilon_d, \varepsilon_p\right\} =$$

$$\exp\left\{-\sum_{k=1}^{t_d} h_{dk} - \sum_{k=1}^{t_p} h_{pk}\right\} \quad (1)$$

where

$$h_{dk} = h_{0dk}(t)\exp\{\beta'_{1d} g_{dk}(H, R, X_C, X_B) + \beta'_{2d} Z + \varepsilon_d\}$$

$$h_{dk} = h_{0pk}(t)\exp\left\{\beta'_{1d} g_{pk}(H, R, X_C, X_B) + \beta'_{2p} Z + \varepsilon_p\right\}$$

The log-integrated hazard function can be also written in the following form as:

$$lh_j = \beta_{0j} + \beta'_{1d} g_j(H, R, X_C, X_B) + \beta_{2j} Z + \beta_{3j} I_j + \beta_{4j} I_j g_j(H, R, X_C, X_B) + \varepsilon_j \quad (2)$$

In this formulation, *S* is a cumulative survival probability conditional on housing price *H*, alternative investment return *R*, vector of macro-economic variables *Z*, and vector of micro variables $g(H, R, X_C, X_B)$. Both *Z* and g are time-varying, where *Z* measures the systematic risk of the market and loan-level information while g measures the intrinsic values of the default and prepayment options. Among g, X_B represents borrower characteristics and X_C stands for collateral information. I_j is a dummy variable equal to unity if the loan is to finance a forward house, and zero otherwise. T_d, T_p are discrete random variables representing the loan life of a mortgage prior to default and prepayment, respectively. h_{ik}, $i = d$, and p are hazard functions; unobserved error terms associated with the hazard functions for default and prepayment are denoted by ε_d and ε_p, respectively, to represent heterogeneities. The Kaplan–Meier approach

was used to fit the empirical hazard rates of prepayment and default based on the entire sample.

Equation 2 assumes, however, that the market effects of Z are the same for both forward mortgages and spot market mortgages. It also assumes that the error structures are the same for all mortgage loans. To accommodate this restriction, a more complete separation regression for the forward market and for the spot market can be estimated similar to Blinder (1973) and Oaxaca (1973).

For the spot market without pre-sale,

$$lh_j^S = \alpha_{0j} + \alpha'_{1j} g_j^S(H, R, X_C, X_B) + \alpha_{2j} Z + \varepsilon_j^S = \alpha_j G_j^S + \varepsilon_j^S \quad (3)$$

For the forward market with pre-sale,

$$lh_j^F = \beta_{0j} + \beta'_{1j} g_j^F(H, R, X_C, X_B) + \beta_{2j} Z + \varepsilon_j^F = \beta_j G_j^F + \varepsilon_j^F \quad (4)$$

where $G_j^i = \left[I g'_j(H, R, X_C, X_B) Z\right]'$ is a column vector of repressors, $j = d, p$ and $i = S, F, \alpha = \left[\alpha_{0j} \alpha'_{1j} \alpha_{2j}\right]$, and $\beta = \left[\beta_{0j} \beta'_{1j} \beta_{2j}\right]$ are regression coefficients.

The log Hazard Ratio, denoted by LHR between two groups of *F* and *S*, can be decomposed into two parts:

$$LHR_j = \overline{\beta G}^F - \overline{\alpha}\overline{G}^S = \overline{\alpha}\left(\overline{G}^F - \overline{G}^S\right) + \overline{G}^F\left(\overline{\beta} - \overline{\alpha}\right) \quad (5)$$

where the upper bar associated with a variable indicates the mean and estimated coefficients. The first part of the risk differential is due to differences in the typical loan characteristics of forward versus spot $\left(\overline{G}^F - \overline{G}^S\right)$, assuming they are valued at the same spot market. The second part of the risk differential reflects the portion of the higher risk on forward market loans that arises because they are priced differently from otherwise identical mortgages for existing house financing.

The default options in the pre-sale period versus the post-sale period are entirely different. In the post-sale period, the default option is related intensively to the housing price.

However, in the pre-sale period, the default option depends mainly on the probability of developer default. Following Deng et al. (2000), the proxy value of exercising the "put option" for a mortgage borrower in the post-sale period is measured by the probability of negative equity.[8] In particular, the variable "put_proxy" is defined as:

$$\text{Put\_Proxy} = N\left(\frac{\log V_r - \log V_H}{\sigma}\right) \tag{6}$$

Where

$$V_r = \sum_{i=1}^{T-k} \frac{M_{\tau+k}}{(1 + r_{\tau+k})^i} \tag{7}$$

$$V_H = P\left(\frac{H_{\tau+k}}{H\tau}\right) \tag{8}$$

V_r is the market value of mortgage debt; M is the monthly payment of mortgage principle and interest, $r_{\tau+k}$ is the adjustable mortgage rate for a loan originated at time τ and after the seasoning period of k. T is the mortgage term. V_H is the market value of a house that is purchased at τ with price P and valued at $\tau + k$; H_τ is the housing price index at time τ in the area. The term in parentheses of Eq. 8 follows a log normal distribution. $N(\cdot)$ is the cumulative standard normal distribution function, and σ is housing index volatility.[9] The calculation of V_r involves calculating an annual re-setting of the monthly payment of principle and interest.

The intrinsic value of the call option is defined as:

$$\text{Call\_Proxy} = \frac{V_r - V_R}{V_r} \tag{9}$$

where V_r, as defined previously, is the market value of a mortgage, the cost of financing a house

[8] Typically one cannot estimate directly which default option is in the money without knowing the entire path of individual house values. However, we can use the initial loan-to-value ratio and the diffusion process of house prices to estimate the critical value for a borrower to exercise the put option, known as the probability of negative equity.
[9] The housing price indices and their volatilities are estimated according to the three-stage procedure originally created by Case and Shiller (1989) and modified by Quigley and Van Order (1995).

purchase, and V_R is the value of hypothetical income, the return from an alternative investment.

Since the stock market is a major investment alternative, the Shanghai stock price index is used in return calculation. Specifically, V_R is defined as:

$$V_R = \sum_{i=1}^{T-k} \frac{M_{\tau+k}(1+R_{\tau+k})^i}{(1+r_f)^i} \tag{10}$$

In addition to the intrinsic value of options, three sets of non-option-related variables are included in the regression. Those variables include time-varying and time-invariant determinants of mortgage performance motivated by our economic model. The first set of variables, denoted by X_B, describe the borrowers' characteristics including gender, age, education, the log value of monthly income from borrowers and their spouses, occupation, marital status, number of dependents in the borrower's household, etc. The second set of variables, denoted by X_C, describes collateral information. The developer-related information includes credit ratings, type of developer, the age of the developer, the equity value of the firm at registration, the size of the developer, the ratio of certified professionals to total employees, and the number of projects, etc. Other loan-related information includes the original loan amount, the down payment rate, the loan-to-value ratio at origination, the year and month, maturity, the size of the house, the location of the property, the sale type, the appraisal value of the property at time of sale, etc.

Empirical Results

The risk analyses are based on the full sample from the combined dataset including bank loans and the real estate developer database. The competing risks of default and prepayment are estimated jointly. Table 6 presents three variations of the competing risks model of loan termination. All specifications incorporate both market variables and a rich set of loan

characteristics including borrowers' characteristics and collateral information. The market variables include time-varying proxies for local economic conditions such as inflation, the unemployment rate, the slope of the term structure of interest rates, stock market returns, etc. Each of the three models contains separate flexible baseline functions for default and prepayment that follow Han and Hausman (1990). The empirical results are different from an earlier assessment of loan performances in China conducted by Deng et al. (2005). Their paper includes only loan performance data; therefore it cannot distinguish pre-sale contracts from contracts on completed property. An important data extension in this paper is that we are able to link each loan to the underlying housing unit and its builder. Therefore, impacts of borrower or developer characteristics on the default (prepayment) probability are conditional on the same contract type (spot or forward). This is in contrast to Deng et al. (2005), who estimate the pooled impact of borrowers on the probability of loan termination.

Model 1 tests both the default rate and the prepayment rate equations following Eq. 2, where the presale dummy is estimated in a hazard regression framework and the interaction term β_4 is constrained as zero. Furthermore, the model does not control directly for the intrinsic value of call and put options in the estimation. Model 1 provides a benchmark for the competing risks specifications discussed below. Model 2 extends model 1 by including the contemporaneous values of options in both the default and prepayment equations. Model 3 further extends model 2 by including interaction terms of pre-sale with a call option and a put option in both risk equations. Overall, the competing risks models are well-specified and control for approximately 40 factors, including market condition and borrower-developer characteristics.

As evidenced in model 1, estimation results indicate that economic conditions in the market have important impacts on default and prepayment behaviors. As a proxy for the overall

economy, the Shanghai Stock Index is negatively associated with default and prepayment. An increase in local unemployment rates positively affects the exercise of the default option and the prepayment option. This result is highly significant across model specifications. The unemployment rate is a macro variable indicating the strength of the macroeconomic environment. It also reflects Chinese borrowers' confidence about job stability and financial soundness. For most Chinese households, housing is a basic form of consumption. When facing uncertainty about future wealth, they will choose to invest in housing rather than in risky stocks and bonds. This is quite different from the situation in the US, where prepayment risk is negatively associated with the unemployment rate. The slope of the term structure of the interest rate, defined as the difference between the 5-year CD rate and the spot rate, discloses expectations about future interest rates. When the yield curve widens, borrowers in China may prefer to prepay mortgage debt. As shown in model 1, while the relationship between default behavior and the slope of the term structure is statistically insignificant, the prepayment rate is negatively associated with the slope of the term structure and statistically significant.

The estimates from model 1 suggest that the loan-to-value ratio at origination is positively associated with the default risk and negatively associated with the prepayment risk. Higher LTV reflects greater liquidity constraint on the part of the purchaser, which means she has less equity invested in the house. Model 1 also shows that the likelihood of default and prepayment, respectively, vary positively with housing-expense burdens proxied by the mortgage-expense-to income ratio.

Model 1 also estimates the effects of borrowers' characteristics, including borrower's age, sex, marital status, education background, occupation and job positions, log monthly household income, and number of dependents in the household. Among these categorical or

continuous variables, household income is an important factor in determining default and prepayment risk. High-income borrowers are less likely to default and more likely to prepay. The log income is highly significant across all three models. Another continuous covariate that is statistically significant is the number of dependents in a household. The more dependents there are in a household, the higher is the burden of the mortgage borrower and thus the higher is the default probability and the lower is the prepayment risk. Among the categorical covariates, sex is insignificant; age is, however, significant across these three models. Older borrowers have relatively lower default risk and higher prepayment risk. Younger people in China are more liquidity constrained and also prefer to smooth consumption by borrowing, reflecting a difference in lifestyle preference in China. Marital status is another significant factor in determining the default and prepayment rates. Married borrowers have both a lower default rate and a prepayment rate reflecting that a family is a more stable and responsible social unit than a single person. Occupations and job positions are significantly associated with prepayment risk. The business and trade industry shows a higher prepayment risk due to relatively volatile income streams, while the research and education sector has a lower risk of prepayment because of its relatively stable income streams. Managers exhibit a relatively higher prepayment risk than technicians and self-employed persons. On the other hand, none of them is statistically significantly associated with defaults. A borrower with a college degree has a lower default risk but a higher prepayment risk.

In addition to borrowers' characteristics, model 1 also finds a significant impact of collateral information on mortgage termination in China. In particular, mortgages on underlying properties built by bigger or older developers exhibit lower default risk. There are two measures of developer size—one is the currency-adjusted value of registered equity and the other is the

total number of employees in a firm. These two size variables are statistically significantly associated with default risk, while the association with prepayment risks is insignificant. New developers tend to be associated with a higher default risk and a higher prepayment risk with respect to mortgage loans. In the study sample period, the Chinese housing sector was experiencing tremendous development, which stimulates more companies to enter into the real estate business. While it is hard for consumers to monitor and judge the quality of properties they are developing, established developers have an operational advantage in this market. Developer quality not only affects the property price, but it also impacts the financial market via the channel of mortgage termination. Developers who are involved in residential real estate development for more than 20 years are associated with lower default risk and higher prepayment risk. The ratio of certified professionals to total developer employees is also significantly associated with mortgage default and prepayment rates. The higher the professional ratio, the lower the default risk and the higher the prepayment risk. A strong developer tends to have more certified professionals and to have passed a higher industry standard (for example ISO 9000) and also to prefer undertaking long-term commitments. Since a developer of good quality tends to exercise better cost management, quality control, and reputation management, its pre-sale houses will show a lower probability of failure of delivery. Therefore mortgages associated with good-quality developers will exhibit lower default risk and higher prepayment rates. Developer type is also associated with different default and prepayment risks. A foreign joint venture developer exhibits lower default risk and higher prepayment risk, while joint ventures with HMT developers are associated with higher default risk. Compared with state-owned developers, private developers and limited liability companies have both higher default risk and higher prepayment risks. The location of a property is also associated with different default and

prepayment risks. In a central city area, due to competition and tighter regulation or monitoring, mortgages with underlying property in a central city area tend to have lower default risk and higher prepayment risk.

Model 2 extends model 1 through the introduction of the option-related time varying covariates into both the default and prepayment equations.[10] The estimates confirm that the put option, measured as the probability of negative equity, is positive and highly significant in the exercise of the default option; the call option value is also positively and highly significant in the exercise of the prepayment option. In other words, with an increase in the probability of negative equity the incidence of default increases dramatically. On the other hand, declines in returns from alternative investments that bring the call option in the money will lead to a high rate of prepayment activities. The stock market in China is a fast-growing investment vehicle that offers returns beyond those of traditional deposits. Investment in the stock market has been showing greater and greater importance in Chinese people's financial decisions. The intrinsic value of the prepayment option in essence reflects a consumer's portfolio choices. Model 2 further indicates that the value of a call option is negatively associated with default risk. In a bull stock market, households may relocate their assets from housing to the stock market by stopping mortgage payments.

Model 3 further includes the interaction term between pre-sale and option values to test whether the intrinsic value of options on the forward market exerts more influence there than on the spot market. The default behavior is less sensitive to the put and call options for mortgage loans with pre-sale properties. For prepayment behavior, the call option and put option are less sensitive to pre-sale mortgage loan borrowers. This means that pre-sale is apparently an

[10] Log Likelihood and the Schwarz-Bayesian Criterion (SBC), reported at the bottom of the table, provide for a comparison of the goodness of fit among alternative models. Models with lower values are considered preferable.

important factor that is highly correlated with both default risk and prepayment risk. If a loan is associated with a forward housing purchase, it is such bad news for the default and prepayment risks that option values (of both call and put) do not add as much to risks as they do in a spot market. The significance in the product terms indicate that the default risk and prepayment risks influence behavior quite differently on the forward market for presale houses and on the spot market.

In similar fashion, product terms between pre-sale and other borrower characteristics and collateral information can be tested. Since mortgages on pre-sale houses exhibit strikingly different default and prepayment behaviors, a more complete separation of hazard regressions is performed towards the forward market and spot market, respectively. Table 7 displays the regression results for the two markets. On the forward market, while the intrinsic value of the call option is significant for exercises of the default option and the prepayment option, the probability of negative equity is associated with neither the default option nor the prepayment option in a statistical sense. The value of the mortgage default option exhibits an entirely different underlying effect among pre-sale houses when compared with its effect on completed projects. On the forward market, the housing price index has little to do with default risk, since the collateral for pre-sale houses is on paper. Therefore the probability of negative equity is more closely associated with houses on the spot market, while houses on the forward market depend more on the probability of house delivery. Another remarkable feature of the separate regressions is that borrowers' characteristics and developer information play different roles on the spot market and the forward market. Borrower characteristics (age, marital status, education, occupation and job position) are only statistically significant on the spot market, while they are not significant on the forward market.

The empirical results reported in Table 7 show that many borrower's characteristics are statistically significant in determining default risks on the spot market. For example, younger borrowers, singles, the elementary school education group, and the social service as well as the self-employment group are associated with higher default risks, while older borrowers, singles, the college education group, and managers are associated with higher prepayment risks. None of these borrower characteristics is, however, statistically associated with mortgage termination risks on the forward market.

On the other hand, developer characteristics (number of projects taken, size, age, and organization structure of the developer) are statistically significant in association with mortgage termination only for pre-sale loans; none of these characteristics is significant on the spot market. For example, developers that have completed more projects in the past and are bigger and more experienced, show a higher ratio of certified professionals to total employees, or are involved in foreign joint ventures associated with lower default risks and higher prepayment risks. None of these developer characteristics is statistically significant in the spot market regression.

Our data shows that among 1,384 default incidences, 84% of the loans are clustered according to projects that involved developer defaults. In addition, all loans associated with development project defaults are defaulted by homer buyers (mortgage borrowers). To capture the potential cluster effect of developer default, we create a developer concentration index (DCI), such that, $DCI = (1 - s)^2$, where s is defined as the ratio of the number of developers involved to the number of loans defaulted or prepaid.[11] On a forward market, the DCI is both economically and statistically significant for defaulted loans, indicating that most defaulted loans

[11] The construction of a DCI index is similar to that of a Herfindahl index. The higher the index, the more concentrated the defaulted loans are to developers.

issued for pre-sale buyers are concentrated in only a few defaulted developers.[12]

Finally, although the sensitivities are different, some loan characteristics, the location variable, and market condition share the same sign across the spot market and forward market. For instance, on both markets, the more dependents there are in a household the higher is the default risk, and the lower is the prepayment risk due to households' liquidity constraints. A central city location enjoys lower default risks and higher prepayment risks.

To demonstrate the mortgage prepayment and default risks with and without embedded forward contract risks, we simulate 300 paths of house price appreciation rates and stock returns according to a joint stochastic mean-reverting process. These 300 randomly sampled paths are applied to the prepayment and default functions reported by model 4 in Table 7 to compute the monthly prepayment and default risks associated with the hypothetical 0.5 million RMB mortgages. We compare two hypothetical mortgage pools characterized by two risk structures between spot and forward market mortgage borrowers. The present values of the cash flows from the two groups allow us to calculate the risk premium on the forward presale housing market (This is similar to Deng and Gabriel 2006). Table 8 reports a simulated result on a forward risk premium that is about 250 basis points per year. This premium is based on market conditions during the period of 1998 to 2003 in Beijing. If stock market returns, the interest rate, or the unemployment rate changes, the premium will certainly be different. However, mortgage performance in our sample shows that the risk premium between the forward and spot markets is both economically large and statistically significant.

[12] It is worthy of mention that a DCI—a measure of developer's local market share—is only one way of proxying the developer's default risk. Other omitted factors, such as developer's default history, local market environment, etc., might also trigger developer default. We thank the editor for pointing this limitation out.

Conclusion

This paper is the first to provide rigorous analysis of mortgage risks on the forward pre-sale housing market. The findings indicate that borrower characteristics and collateral information are both important to determine the mortgage termination risks. Currently most Chinese banks price consumer loans based on borrower characteristics only. The results of this paper indicate a potential improvement in banks' mortgage risk modeling. In addition, mortgage borrowers' prepayment and default behavior in the forward housing market is significantly different from that of the spot housing market. The study finds that the potential difference in risk premium between the forward and spot housing markets in China can be as high as 250 basis points. The findings of this study will provide valuable insights regarding emerging housing and mortgage markets in China as well as those in other transitional economies.

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253–262.

Table 1. Descriptive statistics for mortgage loans frequency of loans by loan category and by payoff types (I)

Variable	Defaulted	Prepaid	Other	All loans
Origination year				
1998	29 (9.27)	84 (26.84)	200 (63.90)	313 (0.30)
1999	10 (0.23)	905 (20.45)	3,511 (79.33)	4,426 (4.28)
2000	392 (2.03)	3,117 (16.16)	15,778 (81.81)	19,287 (18.64)
2001	372 (1.46)	3,165 (12.41)	21,972 (86.13)	25,509 (24.66)
2002	529 (2.18)	1,644 (6.76)	22,132 (91.06)	24,305 (23.49)
2003	52 (0.18)	1,140 (3.85)	28,430 (95.98)	29,622 (28.63)
Total	1,384 (1.34)	10,055 (9.72)	92,023 (88.94)	103,462 (100.00)
Loan to value ratio				
$LTV < 60$	309 (1.33)	2,608 (11.27)	20,232 (87.40)	23,149 (22.37)
$60 \leq LTV < 70$	281 (1.12)	2,538 (10.12)	22,252 (88.76)	25,071 (24.23)
$LTV \geq 70$	794 (1.44)	4,909 (8.89)	49,539 (89.68)	55,242 (53.39)
Original loan amount (OLA)				
OLA < 200,000 RMB	508 (1.40)	3,732 (10.32)	31,938 (88.28)	36,178 (34.97)
200,000 ≤ RMB OLA < 400,0000 RMB	430 (1.37)	2,960 (9.46)	27,892 (89.16)	31,282 (30.24)
OLA ≥ 400,000 RMB	446 (1.26)	3,363 (7.84)	32,193 (84.12)	36,002 (31.53)
Market of transaction				
Spot market	141 (0.53)	628 (2.34)	26,076 (97.14)	26,845 (25.95)
Forward market	1,385 (1.81)	9,427 (12.30)	65,805 (85.89)	76,617 (74.05)

Table 2. Descriptive statistics for mortgage loans frequency of loans by collateral/developer category and by payoff types (II)

Variable	Defaulted	Prepaid	Other	All loans
Rating Group				
1	8 (0.01)	543 (0.63)	3,536 (4.13)	4,087 (4.77)
2	1 (0.01)	1,159 (7.96)	13,404 (92.04)	14,564 (17.01)
3	1 (0.02)	500 (10.51)	4,255 (89.47)	4,756 (5.55)
4	742 (53.57)	65 (4.69)	578 (41.73)	1,385 (1.62)
Unrated	620 (1.02)	4,740 (7.79)	55,479 (91.19)	60,839 (71.05)
Developer Type				
SOE	123 (0.89)	1,310 (9.43)	12,462 (89.69)	13,895 (16.22)
JV_HTM	621 (19.88)	258 (8.26)	2,245 (71.86)	3,124 (3.65)
JV_F	68 (1.46)	404 (8.69)	4,175 (89.84)	4,647 (5.42)
Limited	380 (0.64)	4,675 (7.91)	54,084 (91.45)	59,139 (69.03)
Private	192 (3.95)	359 (7.38)	4,311 (88.67)	4,862 (5.68)
History of Developer				
$<$5 years old	4 (0.01)	2,700 (9.89)	24,598 (90.10)	27,302 (32.33)
$\geq$5 years old	1,334 (2.33)	4,132 (7.23)	51,672 (90.43)	57,138 (67.67)
Currency type of equity				
USD	687 (0.87)	6,447 (8.18)	71,700 (90.95)	6,833 (7.98)
RMB	1,384 (1.62)	7,006 (8.18)	77,277 (90.21)	78,834 (92.02)
Valid period of license				
Short	1,034 (5.46)	1,582 (8.35)	16,325 (86.19)	18,941 (24.30)
Long	321 (0.54)	4,579 (7.76)	54,115 (91.70)	59,015 (75.70)

Table 3. Descriptive statistics for mortgage loans frequency of loans by collateral/developer category and by payoff types (III)

Variable	Defaulted	Prepaid	Other	All loans
Location				
Outer city	244 (2.04)	1,702 (14.20)	10,044 (83.77)	11,990 (11.59)
Inner city	1,140 (1.25)	8,353 (9.13)	81,979 (89.62)	91,472 (88.41)
Quality control standard				
None	1,375 (1.40)	9,445 (9.61)	87,484 (88.99)	98,304 (95.01)
Pass	9 (0.17)	610 (11.83)	4,539 (88.00)	5,158 (4.99)
Positive review by real estate				
None	1,376 (1.33)	9,252 (8.94)	84,888 (82.05)	95,516 (92.32)
Good	8 (0.01)	803 (0.78)	7,135 (6.90)	7,946 (7.68)
Developer and project location				
Different district	1,246 (1.68)	7,752 (10.45)	65,214 (87.88)	74,212 (72.53)
Same district	18 (0.06)	2,178 (7.75)	25,915 (92.19)	28,111 (27.47)
One or two missing	120 (0.12)	79 (0.08)	701 (0.68)	900 (0.87)
Internal monitoring				
Strong	778 (1.62)	3,633 (7.57)	43,576 (90.81)	47,987 (56.00)
Weak	606 (1.61)	3,379 (8.96)	33,726 (89.43)	37,711 (44.00)
Quality control standard				
None	1,375 (1.40)	9,445 (9.61)	87,484 (88.99)	98,304 (95.01)
Pass	9 (0.17)	610 (11.83)	4,539 (88.00)	5,158 (4.99)

Table 4. Descriptive statistics for mortgage loans frequency of loans by category and by payoff types (IV)

Variable	Defaulted	Prepaid	Other	All loans
Positive review				
None	1,376 (1.33)	9,252 (8.94)	84,888 (82.05)	95,516 (92.32)
Good	8 (0.01)	803 (0.78)	7,135 (6.90)	7,946 (7.68)
Professional ratio				
Low	757 (3.86)	1,690 (8.61)	17,177 (87.53)	19,624 (22.94)
High	616 (0.93)	5,306 (8.05)	59,998 (91.02)	65,920 (77.06)
Developer size				
Number of employee < 30	1,318 (3.07)	3,333 (7.76)	38,314 (89.17)	42,965 (50.22)
Number of employee ≥ 30	55 (0.13)	3,665 (8.60)	38,875 (91.27)	42,595 (49.78)
Registered equity				
Equity $<$ 30 million RMB	1,268 (3.46)	2,872 (7.84)	32,497 (88.70)	36,637 (42.78)
Equity $\geq$ 30 million RMB	57 (0.12)	4140 (8.45)	44,805 (91.44)	49,002 (57.22)
Number of projects				
Single property	1,373 (2.10)	6,592 (10.07)	57,495 (87.83)	65,460 (63.42)
Multiple properties	11 (0.03)	3,417 (9.05)	34,335 (90.92)	37,763 (36.58)

Table 5. Descriptive statistics for mortgage loans frequency of loans by borrower category and by payoff types

Variable	Defaulted	Prepaid	Other	All loans
Marital status				
Married	562 (1.21)	4,277 (9.24)	41,440 (89.54)	46,279 (44.73)
Single	822 (1.44)	5,778 (10.10)	50,583 (88.46)	57,183 (55.27)
Education				
College	843 (1.30)	6,432 (9.92)	57,563 (88.78)	64,838 (62.67)
Secondary school	482 (1.38)	3,254 (9.32)	31,195 (89.30)	34,931 (33.76)
Primary school	59 (1.60)	369 (9.99)	3,265 (88.41)	3,693 (3.57)
Age cohort				
Age <40	1,036 (1.29)	6,574 (8.21)	72,420 (90.49)	80,030 (77.35)
Age ≥40	348 (1.49)	3,481 (14.86)	19,603 (83.66)	23,432 (22.65)
Income groups (monthly)				
<8,888 RMB	1,006 (1.31)	6,623 (8.60)	69,403 (90.10)	77,032 (74.45)
≥8,888 RMB	378 (1.43)	3,432 (12.99)	22,620 (85.58)	26,430 (25.55)
Occupation				
Business/trade	248 (1.11)	1,854 (8.27)	20,303 (90.62)	22,405 (21.66)
Social service	130 (1.33)	849 (8.72)	8,759 (89.95)	9,738 (9.41)
Self-employment	602 (1.42)	4,960 (11.72)	36,746 (86.85)	42,308 (40.89)
R&D	80 (0.81)	773 (7.82)	9,038 (91.38)	9,891 (9.56)
Others	324 (1.69)	1,619 (8.47)	17,177 (89.84)	19,120 (18.48)
Job position				
Manager	768 (1.22)	6,184 (9.86)	55,766 (88.92)	62,718 (60.62)
Others	214 (10.77)	607 (16.76)	5,457 (172.48)	6,278 (6.07)
Technician	168 (1.21)	1,256 (9.03)	12,482 (89.76)	13,906 (13.44)
Clerk	234 (1.14)	2,008 (9.77)	18,318 (89.10)	20,560 (19.87)

Table 6. Maximum likelihood estimates for competing risks of Chinese adjustable rate mortgage prepayment and default

	Model 1		Model 2		Model 3	
	Default	Prepay	Default	Prepay	Default	Prepay
Fraction of contract value			−2.616	2.722	−3.017	4.618
(Call option)			(11.93)	(30.49)	(5.80)	(21.45)
Probability of negative equity			3.967	2.105	3.533	5.377
(Put option)			(5.69)	(13.13)	(9.55)	(10.04)
Presale (Dummy)	1.058	1.118	1.013	1.097	1.090	1.020
Interaction of presale and call option					−1.937	−2.029
					(7.42)	(8.86)
Interaction of presale and put option					−3.103	−3.462
					(7.54)	(6.45)
Age ≥ 40	−0.283	0.105	−0.280	0.111	−0.245	0.103
	(4.65)	(4.73)	(4.54)	(4.96)	(3.93)	(4.61)
Female (dummy)	−0.044	0.009	0.010	0.020	0.007	0.022
	(0.82)	(0.44)	(0.18)	(1.02)	(0.13)	(1.12)
Married (dummy)	−0.017	−0.057	−0.027	−0.064	−0.058	−0.067
	(1.29)	(2.85)	(1.42)	(3.15)	(1.97)	(3.28)
Occupation: business and trade (dummy)	−0.077	0.051	−0.095	0.050	−0.022	0.045
	(0.84)	(1.96)	(1.03)	(2.33)	(0.24)	(1.94)
Occupation: social service (dummy)	0.070	0.013	0.943	0.018	0.054	0.013
	(0.70)	(2.33)	(0.44)	(1.95)	(0.53)	(0.33)
Ocupation: others (dummy)	−0.141	0.060	−0.180	0.047	−0.106	0.045
	(1.78)	(2.15)	(0.23)	(2.62)	(1.32)	(1.61)
Occupation: R&D (dummy)	0.017	−0.033	0.040	−0.024	−0.136	−0.022
	(0.15)	(2.84)	(0.34)	(2.17)	(1.15)	2.06
Education: secondary school (dummy)	−0.102	−0.083	−0.110	−0.046	−0.056	0.044
	(0.78)	(1.55)	(0.83)	(0.86)	(0.42)	(0.82)
Education: college (dummy)	−0.149	0.119	−0.158	0.108	−0.127	0.106
	(2.63)	(5.37)	(2.78)	(4.86)	(2.23)	(4.79)
Job position: manager (dummy)	−0.021	0.045	−0.019	0.036	−0.025	0.036
	(0.24)	(2.71)	(0.22)	(2.18)	(0.29)	(2.36)
Job position: technician (dummy)	0.013	−0.063	0.031	−0.049	0.082	−0.051
	(0.12)	(1.98)	(0.29)	(1.95)	(1.76)	(1.45)
Number of dependents	0.229	−0.568	0.224	−0.550	0.213	−0.549
	(20.63)	(50.02)	(20.09)	(48.49)	(18.67)	(48.40)
Log monthly income	−0.100	0.130	−0.103	0.123	−0.152	0.122
	(2.60)	(6.62)	(1.63)	(6.07)	(2.40)	(6.03)
Multiple project	−1.829	0.077	−1.748	0.119	−1.868	0.116
(Dummy)	(10.68)	(3.35)	(10.08)	(5.14)	(2.40)	(5.03)
Size (In 10 mil. currency Adj.)	−0.104	0.000	−0.099	0.000	−0.099	0.000
	(6.31)	(0.79)	(5.96)	(0.31)	(6.44)	(0.51)
Number of employee	−0.063	0.000	−0.060	0.000	−0.061	0.000
	(15.82)	(1.58)	(15.25)	(1.43)	(15.37)	(1.00)
License longer than 20 years (dummy)	−0.458	0.152	−0.426	0.105	−0.502	0.103
	(3.86)	(6.89)	(3.57)	(4.72)	(4.15)	(4.64)
New developer (dummy)	2.431	0.123	2.499	0.117	2.457	0.118
	(9.80)	(5.13)	(9.83)	(4.89)	(9.57)	(4.94)
Developer type: joint	−0.936	0.056	−0.987	0.130	−0.934	0.128

venture w/ foreign developer (dummy)	(7.16)	(1.14)	(7.37)	(2.68)	(6.96)	(2.63)
Developer type: joint venture w/ HK, Macau, TW (dummy)	0.834 (8.59)	−0.059 (0.87)	0.844 (8.63)	−0.049 (0.72)	0.800 (8.20)	−0.039 (0.58)
Developer type: private developer (dummy)	0.196 (1.14)	0.158 (2.68)	0.295 (1.72)	0.157 (2.66)	0.299 (1.78)	0.150 (2.55)
Developer type limited co. (dummy)	0.504 (5.03)	0.094 (2.36)	0.451 (4.48)	0.101 2.56	0.506 (4.99)	0.105 (2.65)
Central city location (dummy)	−1.306 (9.55)	0.086 (3.38)	−1.224 (8.93)	0.084 (3.30)	−1.271 (9.18)	0.085 (3.35)
Ratio of certified professionals	−4.501 (9.55)	0.256 (5.38)	−4.402 (18.38)	0.269 (5.67)	−4.470 (18.51)	0.271 (5.71)
Loan to value ratio	0.068 (1.70)	−0.043 (3.25)	0.046 (3.08)	−0.073 (4.11)	−0.003 (0.06)	−0.074 (4.12)
Housing expenditure to income ratio	0.578 (9.95)	−0.363 (12.68)	0.537 (9.08)	−0.352 (12.43)	0.360 (5.89)	−0.343 (12.13)
Log loan amount	0.129 (0.99)	−0.117 (1.87)	0.047 (0.72)	−0.190 (1.36)	−0.061 (0.92)	−0.191 (1.53)
Stock market	0.002 (1.79)	−0.005 (39.45)	0.002 (0.50)	−0.005 (39.50)	0.002 (1.43)	−0.005 (39.36)
Term structure slope	−0.494 (2.16)	−1.549 (48.74)	−0.762 (3.11)	−1.512 (47.30)	−0.649 (2.65)	−1.511 (47.28)
Unemployment	0.059 (7.69)	0.081 (48.20)	0.046 (5.44)	0.077 (46.21)	0.053 (6.27)	0.076 (46.01)
Log likelihood	165,089		164,254		164,107	
SBC	165,545		164,747		164,638	

Table 7. Maximum likelihood estimates for competing risks of Chinese adjustable rate mortgage prepayment and default

	Model 4: Spot market		Model 4: Forward market	
	Default	Prepay	Default	Prepay
Fraction of contract value (call option)	−0.264 (1.39)	3.846 (9.58)	−2.333 (9.14)	2.536 (27.60)
Probability of negative equity (put option)	9.155 (2.33)	2.809 (2.03)	2.789 (0.87)	2.096 (0.55)
Age ≥ 40 (dummy)	−0.500 (2.01)	0.140 (2.41)	−0.218 (1.97)	0.118 (1.67)
Female (dummy)	−0.073 (1.29)	−0.012 (1.13)	0.023 (0.40)	0.024 (1.19)
Married (dummy)	−1.536 (4.06)	−0.200 (2.42)	−0.136 (1.17)	−0.054 (1.59)
Occupation: business and trade (dummy)	−0.678 (1.79)	0.138 (1.02)	−0.022 (0.23)	0.037 (1.14)
Occupation: social service (dummy)	0.922 (2.33)	0.082 (0.50)	−0.008 (0.08)	0.002 (0.04)
Occupation: others (dummy)	−0.643 (1.94)	0.150 (1.34)	−0.152 (1.97)	0.036 (1.37)
Occupation: R&D (dummy)	0.064 (0.16)	−0.118 (0.70)	−0.081 (0.63)	0.012 (0.30)
Education: secondary school (dummy)	−0.848 (2.03)	−0.131 (0.57)	0.006 (0.05)	−0.039 (0.72)
Education: college (dummy)	−0.470 (3.94)	0.121 (3.15)	0.041 (0.92)	−0.100 (1.74)
Job position: manager (dummy)	−0.001 (0.00)	0.027 (1.99)	0.055 (0.55)	−0.046 (1.52)
Job position: self-employment (dummy)	0.983 (2.00)	−0.160 (1.89)	1.028 (1.41)	−0.065 (1.26)
Job position: technician (dummy)	0.351 (0.54)	0.058 (0.29)	0.093 (0.64)	−0.075 (1.60)
Number of dependents	0.791 (6.19)	−0.734 (13.61)	0.218 (14.08)	−0.528 (43.99)
Log monthly income	−0.194 (2.00)	0.228 (2.73)	−0.105 (1.60)	0.116 (5.43)
Multiple project (dummy)	−0.144 (0.47)	−0.061 (0.63)	−2.540 (8.13)	0.123 (5.10)
Size (in 10 mil. currency adj.)	−0.024 (2.49)	0.004 (2.96)	−0.216 (14.15)	0.000 (0.07)
Number of employee	−0.004 (0.58)	0.000 (0.08)	−0.065 (11.30)	0.000 (2.40)
License longer than 20 years (dummy)	−0.078 (0.32)	−0.007 (0.09)	−0.244 (2.13)	0.099 (5.41)
New developer (dummy)	0.158 (0.32)	0.033 (0.34)	3.600 (6.17)	0.116 (4.70)
Developer type: joint venture w/ foreign developer (dummy)	17.359 (0.00)	0.026 (0.13)	−0.828 (6.01)	0.134 (2.61)
Developer type: joint venture w/ HK, Macau, TW (dummy)	23.196 (0.00)	0.412 (1.46)	0.817 (7.63)	−0.068 (1.98)
Developer type: private developer (dummy)	17.854 (0.00)	0.025 (0.11)	0.308 (1.79)	0.153 (2.54)
Developer type: limited co. (dummy)	21.694 (0.00)	0.061 (0.35)	0.522 (4.49)	0.131 (2.93)
Central city location (dummy)	−0.101 (2.18)	0.074 (2.55)	−2.693 (8.40)	0.111 (3.27)
Ratio of certified professionals	0.003 (0.00)	−0.016 (0.08)	−4.410 (16.77)	0.269 (5.55)
Loan to value ratio	0.947 (2.83)	−0.125 (1.62)	−0.045 (0.87)	−0.072 (3.81)
Housing expenditure to income ratio	1.215 (8.59)	−0.790 (7.15)	−0.006 (0.10)	−0.330 (13.65)
Developer concentration index[a]	−0.319 (0.93)	0.246 (1.02)	0.401 (16.40)	0.296 (1.15)

Log loan amount	1.514 (5.25)	−0.252 (3.07)	−0.199 (2.95)	−0.184 (8.79)
Stock market	0.010 (0.17)	−0.008 11.48	0.002 (5.88)	−0.005 (36.64)
Slope term structure	3.373 (0.00)	−1.446 (9.94)	−0.526 (2.23)	−1.389 (44.59)
Unemployment	2.012 (0.01)	9.707 (2.88)	6.065 (7.75)	8.289 (53.07)
Log likelihood	10,533		165,492	
SBC	11,454		170,943	

t-ratios are in parentheses

[a] Developer concentration index (DCI) is defined as follows, where s is defined as the ratio of number of developers involved over number of loans defaulted (prepaid)

Table 8. Risk premium of forward mortgage over spot mortgage

	1-year seasoned	2-year seasoned	5-year seasoned
Risk Premium	1.85%	2.49%	2.31%
T-Ratio	(5.93)	(45.28)	(8.57)

t-ratios are in parentheses. The simulated market values are computed based on model 4 in Table 7, together with joint processes of stock market and housing prices

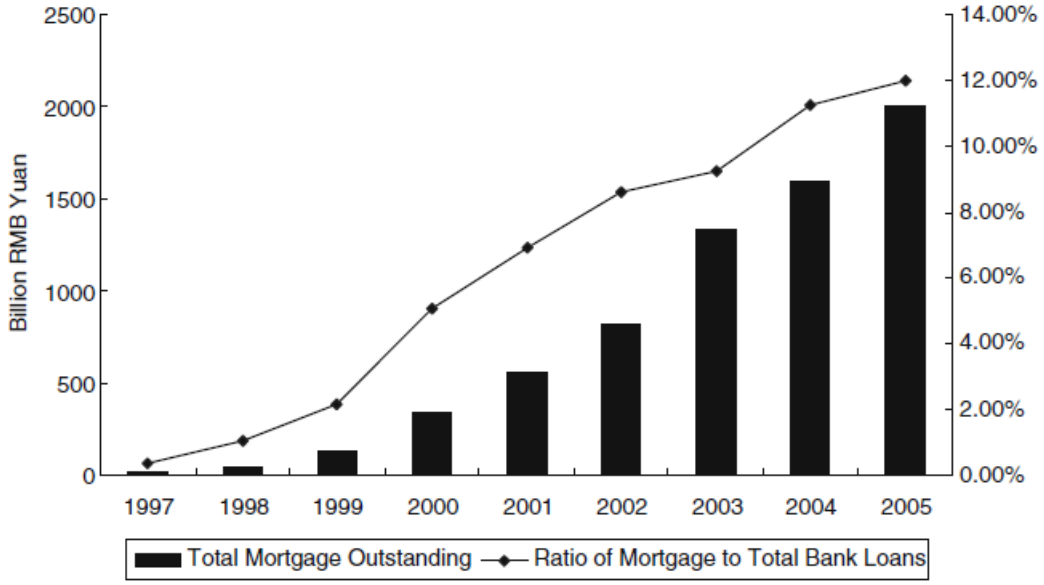

Figure 1. Residential mortgage market in China

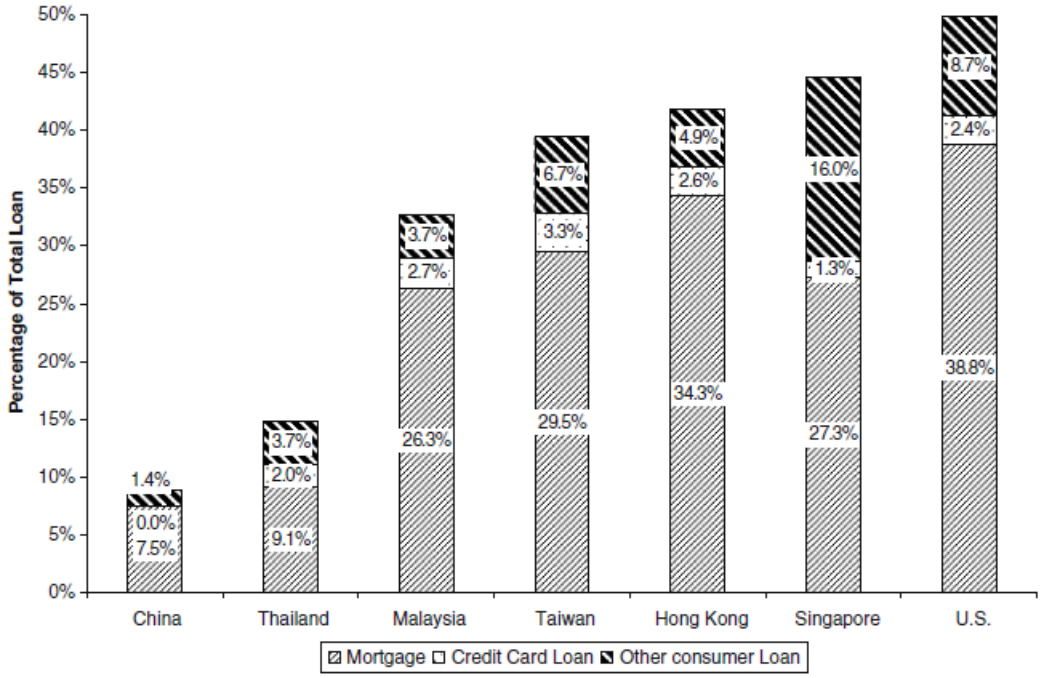

Figure 2. International comparison of mortgage to consumer loan ratio (2003)

Simple Model for Forward v.s. Spot Housing Market in China

1. Forward Housing Market

Pre-Sale Period

Time Line	T=0 Transaction Date	T=1 House Delivery Date	T=2 Option Exercise Date	T=3 Mortgage Maturity
Customer	1.Purchase House on Forward Market 2. Pay in full to Developer with Downpayment+Mortgage	1. Take Delivery of pre-sale House and Pay Mortgage to Bank 2. Default Mortgage if Developer Fails to Deliver Pre-sale House 3. Consume Housing	1. Prepay if Financing Cost>Investment Return 2. Default if Value of House<Value of Mortgage 3. Not Exercise Prepayment Option if Borrower is Constrained 4. Consume Housing	1. Payment of Last mortgage payment 2. Consume Housing
Developer	1. Receive House Price in Full 2. Deposit in Bank 3. Develop Pre-Sale House	1. Deliver Pre-Sale House in Good Market 2. Default in Bad Market 3. Sell Completed House on Spot Market		
Bank	1. Mortgage Lending Based on Borrower Characteristics 2. Take Deposit from Developer	1. Receive Mortgage, if Borrower does not Default 2. Receive Residual Value of house if Borrower Defaults	1. New ARM Rate Announced 2. Prepayment Risk, Receive Payment at Par 3. Receive Residual Value of House in Case of Borrower Default 4. Receive Mortgage Payment if Option not Exercised	1. Receive Last Mortgage Payment

2. Spot Housing Market

Time Line	T=1 Transaction/Delivery Date	T=2 Option Exercise Date	T=3 Mortgage Maturity
Customer	1. Purchase House on Spot Market 2. Pay in full to Developer with Downpayment+Mortgage 3. Consume Housing	1. Prepay if Financing Cost>Investment Return 2. Default if Value of House<Value of Mortgage 3. Not Exercise Prepayment Option if Borrower is Constrained 4. Consume Housing	1. Payment of Last 2. Consume Housing
Developer	1. Receive House Price in Full 2. Deposit in Bank		
Bank	1. Mortgage Lending Based on Borrower Characteristics 2. Take Deposit from Developer	1. New ARM Rate Announced 2. Prepayment Risk, Receive Payment at Par 3. Receive Residual Value of House in Case of Borrower Default 4. Receive Mortgage Payment if Option not Exercised	1. Receive Last Mortgage Payment

Figure 3. Market microstructure of forward and spot housing market in China

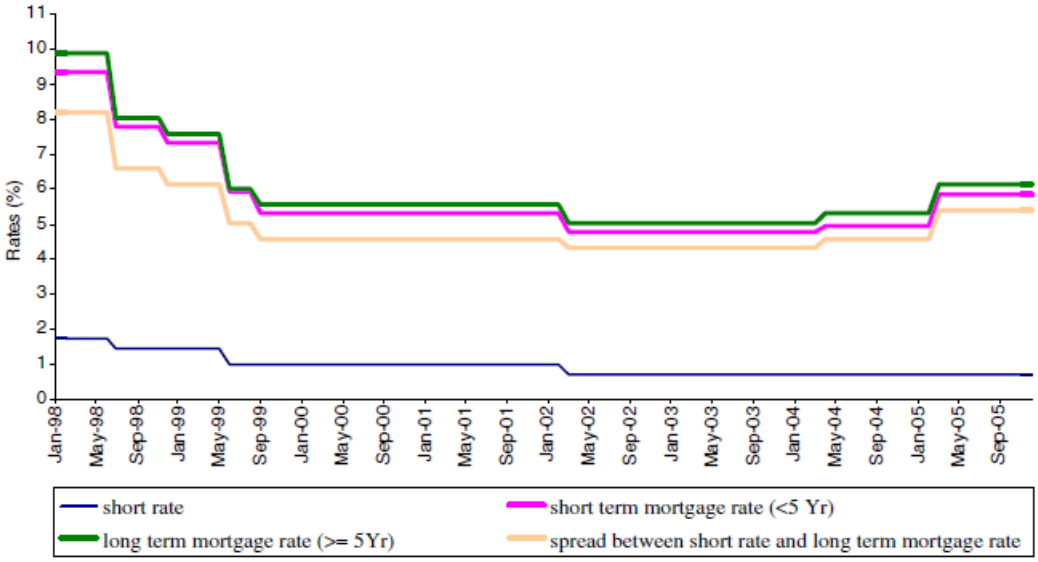

Figure 4. Interest rate and mortgage rates in China

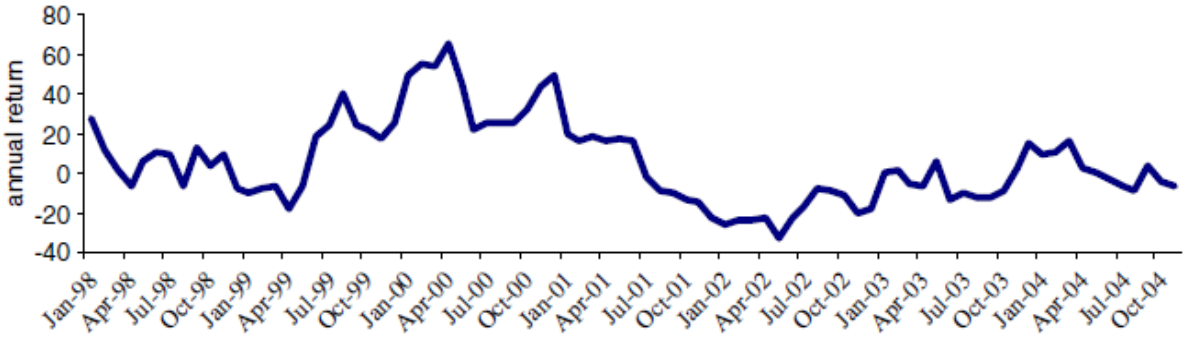

Figure 5. Stock index return in Shanghai, China