Consumer Credit and Residential Mortgage Finance in the US

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1. Introduction

Fast growth in consumer lending in recent years urgently calls for the development of a healthy and efficient consumer credit reporting system, the corresponding institution and organizations, and required legal and regulatory apparatus in China. Standardized consumer credit reporting and its broadened usage support many consumer-lending industries. The papers in this panel cover a broad spectrum of business applications where consumer credit reporting system and consumer credit scoring are instrumental. In this article I focus on how consumer credit reporting and credit modeling are used in residential mortgage finance industry in the US.

Housing sector reform in China has been going on for over a decade. More and more Chinese families will consider buying their homes on mortgage loans. Many Chinese economists and policy makers realize that promoting homeownership can be an engine of capital accumulation that helps build the middle class. Housing requires money from banks for mortgages. For the foreseeable future, these funds have to rely on domestic sources. Today Chinese housing finance system (and the financial market in general) is still at a very primitive stage. The source of mortgage funds is still primarily the deposits of banks. A lot of issues are yet to be addressed. Lenders need to quickly learn how to measure credit risks in a mortgage, how to make lending decisions from a vast pool of applicants, how to get compensated in bearing those risks from investing in residential mortgages, and most importantly, how to ask other investors to share the burden of those risks.

The US experience and practice provide a helpful reference for Chinese policy makers and practitioners to consider. In this article, I provide some institutional and historical backgrounds of US mortgage industry, discuss the various credit risk models, and how different mortgage lending decisions are made. The central theme is to illustrate the mutual dependency between consumer credit reporting and mortgage lending: how the development of one helped the development of the other.

It should be pointed out that accurate credit information is important not only for lenders to make better lending decisions as what loan applications to approve, but also for the loans to be sold in the capital market so that the underlying risk can be commonly understood and shared by a broader investor base.

It should be also be pointed out that the US mortgage finance industry is not only most advanced in the world but also rather unique. The US is about the only country in the world that a consumer can borrow long-term, low-down-payment, and fully-amortizing fixed rate mortgage (FRM) toward purchasing a home. With an FRM, the creditor/investor assumes the interest risk while there is typically no prepayment penalty for the borrower. Compared with other OECD countries, the US has by far the highest

homeownership rate. One noticeable difference is that in the US, there exist giant entities called government sponsored enterprises (GSEs) that play big roles in mortgage finance industry. This article will pay close attention to these GSEs, especially why they are created, what they do, and what impact they have on the whole industry.

The rest of the article is organized in five sections. In Section 2, I provide a bird-eye view of residential mortgage lending and mortgage finance industry in the US. The purpose is to introduce the main players in both the primary mortgage market and the secondary mortgage market. The focus will be on how mortgage lenders and mortgage finance companies work with consumer credit reporting agencies and how information is communicated and transmitted.

In Section 3, I describe a few statistical models of credit risk used in the mortgage industry. In particular I discuss the general form of generic credit scoring that measures the credit worthiness of a borrower, the mortgage-specific credit score that measures the total credit risk embeddied in a mortgage, and a completing-risks model that measures the total risks (credit as well as interest risk) in holding a mortgage as an asset.

Section 4 I review how consumer credit score is used, separately, in loan underwriting, in credit pricing, and in loss mitigation. I illustrate how the mortgage risks are shared and diversified in the market place and by market participants.

Section 5 closes with some policy suggestions for Chinese housing market.

2. The Mortgage Finance Industry in the US

Today more than two thirds of American households are homeowners.[2] For many Americans, becoming a homeowner is a main part of the "American Dream". Buying a home is also the largest financial decision a typical household has to make. In America houses are typically purchased with borrowed money with various level of down payment. A homeowner borrows money by taking out a loan from a lender with the purchased residential property as a collateral for the loan. This lending instrument is called a mortgage. Mortgage finance industry normally refers to the broad sector that channels fund from investor to the borrower, that support the monthly payments by the borrower to the investor until the mortgage contract is terminated.

According to US laws, a mortgage lender has the first lien against the collateral property. Should the borrower get serious delinquent during the life of the loan, the lender has the right to foreclose the property. The legal procedures of the property foreclosure slightly vary across states.

US mortgage finance industry is huge. As the end of 2003, the total residential mortgage outstanding totaled to US $7.8 trillion.

[2] As of December 31, 2003, the homeownership rate was registered at 68.5%. This is by far the highest among the OECD countries.

2.1 Overview

A. Various Types of Mortgage Products

The "Note" is a signed legal document about the mortgage contract that specifies the terms of borrowing and lending agreement. After many decades of evolution and innovation, a borrower today has many mortgage products to choose from. Here is only a partial list:

- 30-Year Fixed Rate Mortgage (FRM) follows a 30-year amortization schedule with the interest rate fixed for the entire life of the loan. More specifically, according to the fixed note rate, the borrower makes 360 equal monthly payments of principal and interest. Mathematically,

(1) $$[A(1+ r/12) – x) *(1+ r/12) – x] \ldots =0$$

  where A is the loaned amount (the origination balance), r is the annual interest rate (called the note rate of the mortgage), x is the monthly payment, and there are 360 x's in the left-hand side. Each monthly payment covers (1) the newly accrued interest that is equal to last month's unpaid balance times the monthly interest rate r/12; and (2) part of the principal. As the unpaid balance decreases with each payment, the interest portion of the payment decreases. With the final and the 360^{th} payment, the unpaid balance reduces to zero. The loan is therefore paid off. It is worth pointing out that a 30-year mortgage rarely pays off that way. Today a mortgage typically has no prepayment penalty to the borrower. Instead of paying exactly x dollars every month, the borrower has the freedom to pay more than x, any extra payment reduces the unpaid balance faster than the schedule. As a matter of fact, borrowers often pay off the entire loans prematurely. (Section 3.3 discusses the reasons why a borrower does that).

- 15-Year FRM. Same as above only with 15-year amortization and therefore180 equal monthly payments of principal and interest.

- Adjustable Rate Mortgage (ARM): 30-year amortization schedule with 360 non-equal monthly payments. Interest rate will be adjusted annually in reference to the prevailing interest rate index.

- Hybrid Mortgage. 30-year amortization schedule with 360 monthly payments. The interest rate is fixed for the first few years and becomes adjustable after that. (It is called 7-1 ARM if the fixed-rate period is 7 years, or 5/1 ARM if the fixed-rate period is 5 years, etc.)

- Interest Only Mortgage (IO): There is no amortization. Every month only the interest is due. When the term is due (Balloon date) the full balance is paid back.

These are only a few main categories. For an ARM, the contract also defines which benchmark interest index is used (LIBOR, Treasure Bond, etc.).

B. Mortgage Segments

The US mortgage market can be grouped at least in three dimensions:

- Jumbo loans versus conforming loans (based on loan amount): Because of the existence of the Fannie Mae and Freddie Mac[3], the mortgage market is segmented by loan amount. Every year a conforming loan limit is set. All mortgages below that limit are called the conforming loan market where the two GSEs play a major role. All mortgages above that limit is nicknamed as the Jumbo market.

- Government loans versus conventional loans (based on government involvement in the risk guarantee). As an important public policy of the US government, the Department of Housing Urban Development (HUD) has a mission to provide credit risk guarantees and financial assistance to certain homebuyers. For example FHA loans, VA loan program to help retired military personals. All others loans not covered by the government agencies are labeled as conventional loans.

- Prime loans and subprime loans (based on risk scale). This distinction is not as clear cut. Typically a prime loan has relative low credit risk. A sub-prime loan typically has higher credit risk. A subprime borrower usually pays more for the same mortgage product (2-3% higher in note rate).

C. Brief History

Up to the 1930's, most American families borrowed directly from local savings and loan institutions to finance home purchases. Lending institutions relied on bank deposits to fund mortgage lending. Loan terms were less than 10 years and at the end of the term, a big balloon payment would come due that included the entire remaining unpaid balance. In an ideal circumstance, at the "balloon" date, the borrower would take another loan out to repay the unpaid balance (this activity is called a refinance). During the Great Depression, more than 1.5 million households lost their homes – even though many have never missed a monthly mortgage payment. This is because that when their mortgage term expired, many could not secure another mortgage from their local banks. There was simply no money available.

In response, US federal government sought to solve these problems and to foster homeownership by expanding the supply of reliable long-term mortgage financing. One of the most important innovations was the introduction by the Federal Housing Administration of long-term FRMs. Since many financial institutions would not, and

[3] Two gigantic mortgage finance companies called Government Sponsored Enterprises (GSEs). We will spend some time to describe their history and explain their roles in Section 2.1.C below.

could not, originate these mortgages or keep them on their books[4], the government created a special agency nicknamed "Fannie Mae" in 1938 to provide the secondary market for these loans.[5]

For the first 30 years, Fannie Mae was charged with the responsibility for creating a liquid secondary market for mortgages by primarily purchasing loans underwritten and issued by Federal Housing Administration. In 1968, Fannie Mae began its transition to a completely private company. That year, the Congress split Fannie Mae into two: the Fannie Mae of today, a federally chartered corporation, wholly owned by private shareholders and publicly traded on New York Stock Exchange; and Ginnie Mae (Government National Mortgage Association), a government corporation within the US Department of Housing and Urban Development (HUD).

To create competition, Congress created Freddie Mac (Federal Home Loan Mortgage Corporation) in 1970. Both Fannie Mae and Freddie Mac were given permission to purchase conventional mortgages (mortgages that are outside of FHA) within the conforming loan limit that is annually adjusted. Both companies have experienced astronomical growth in their (relatively) short history of existence and are now among the largest corporations in the US. Owning in portfolio and securitizing more than a 1/4 of mortgages originated in the US, the Washington D.C. based Fannie Mae is the largest investor in home mortgages and the largest non-bank financial services company in the world.

Fannie Mae and Freddie Mac, two government-sponsored enterprises (GSEs), carry a public mandate of helping low and moderate income Americans, minorities, and Americans in underserved areas to realize home ownership. Both companies are under regulation and oversight from the federal government. Loans purchased or securitized by Fannie Mae and Freddie Mac must meet specific requirements including conforming loan limit. The conforming loan limit is set every year based on national average housing price. In 2004, the loan limit for one-unit single-family homes is $337,200.

Fannie Mae and Freddie Mac are unique. None of other OECD countries has firms like them. Throughout the rest of the paper, the impact of the two firms in the entire mortgage finance industry will be attentively indicated.

2.2 The Primary and the Secondary Mortgage Markets

It has long gone since the days when mortgage lending involved only the borrower (homeowner) and the lender (a local bank). Rather the mortgage industry involves a lot of different financial institutions and financial instruments that help channel investors'

[4] For a Long-term, fully amortizing FRM loan contract, the lender assumes the interest risk together with the credit risk. The two types of risk embedded in a mortgage will be further explained in Section 3.3 below. Private financial institutions viewed this instrument as too risky to own.

[5] The official name of Fannie Mae is Federal National Mortgage Association.

money into the sector and obtain additional funds for mortgage lending. To a great degree, the investor(s) of a mortgage never directly face the borrower.

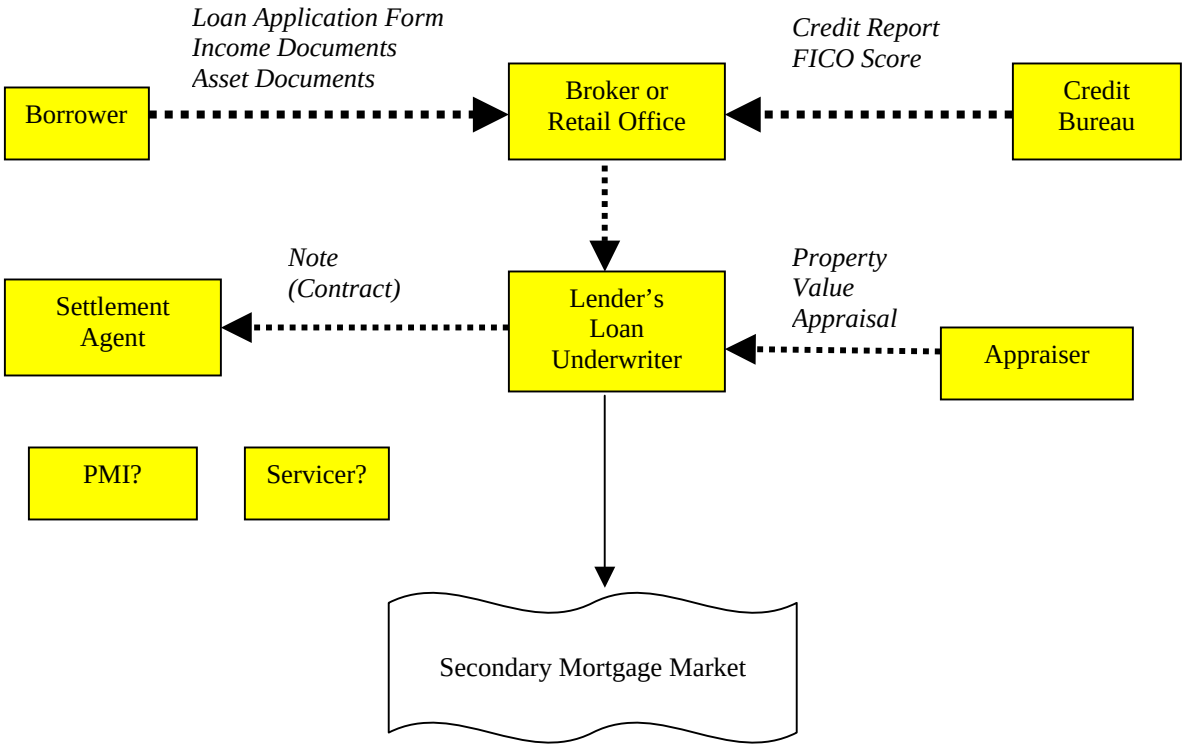
The housing finance system consists of two separate markets: the primary mortgage market and the secondary mortgage market. In the primary market, mortgage contracts are created and funds are loaned directly to borrowers. In the secondary market, lenders and investors buy and sell existing mortgage loans and mortgage-backed securities (MBS). In the rest of this section we introduce various players by describing the loan origination process in the primary market and the loan financing process in the secondary market.

A. The Primary Mortgage Market

In the primary mortgage market, potential homebuyers borrow money from mortgage lenders who are usually subsidiaries of commercial banks, credit unions, and thrifts. In the US there are thousands of mortgage lenders. The top lenders are names like Washington Mutual, Citibank Mortgage, Wells Fargo, JP Morgan Chase, Bank of America, General Electronic, and Countrywide.

Before the money is actually handed to the borrower, there is a lengthy and rigorous loan origination process. Figure 1 below depicts the origination process of a typical mortgage.

Figure 1. Loan Origination Process



To initiate the mortgage origination, the potential borrower applies for a loan at mortgage retail shop (or local bank branch or mortgage broker's office) by completing a uniform loan application form and submitting a set of required documents on the borrower's income and financial assets. The mortgage broker requests the borrower's credit reports from a credit bureau, at the borrower's expense, and submits the application package to the loan underwriter with a proposed loan terms. Keep in mind that there are many types of mortgage products for the borrower to choose from. The loan underwriter reviews the files for completeness and approves the loan conditional upon the collateral value appraisal, based on predetermined underwriting guidelines.[6]

Once the underwriter approves a loan application, a settlement date is determined. The borrower hires a lawyer who serves the clearing agent where all the files are reviewed and signed and funds are cleared and changed hands. Typically the loan settlement is also used as the deed transaction (for a purchase transaction) whereby the buyer takes over the ownership of the property while the seller takes the sale proceeds.

In addition to the borrower, the lender/broker, the property appraiser, the settlement agent, and the credit bureau mentioned above, there are other parties involved in the underwriting process. Other important players include mortgage insurance company. If a loan's loan-to-value (LTV) ratio is greater than 80 percent, federal law requires that the loan to be covered with primary mortgage insurance (PMI). A PMI company provides insurance services should the borrower default on the mortgage payment and the investors of that mortgage suffer a loss. The borrower typically pays the PMI premium so it is extra cost to the borrower. Recently financial-savvy borrowers have the ability to borrow the first mortgage at 80-percent LTV so that to avoid the PMI and simultaneously borrow a second mortgage from a different lender (called second-lien mortgage or home equity loan) to cover the extra money needed in financing the house. A second-lien typically carries a much higher interest rate.

Every loan must be serviced. Servicing a mortgage involves collecting monthly payment from the borrower and forwarding proceeds to the relevant parties; sending notices to the borrower when the payment is overdue, keeping monthly payment records, and initiating foreclosure procedure when default is triggered. Not every lender services loans they originate. If not, a separate service company is also recognized at the loan settlement.

B. The Secondary Mortgage Market

After the loan settlement, the lender then decides whether to keep the loan in its own portfolio as an income-generating asset or to sell the loan to other investors. The market wherein mortgages are sold and bought is the secondary mortgage market.

Although some mortgage lenders directly invest in mortgages, the majority of the mortgages are sold to other investors. If mortgage banks hold their mortgage offering in

[6] Starting from the mid 1990's, electronic file transmission via the internet and automated loan underwriting took off and advanced very quickly.

their portfolio, they finance these mortgages by either depositary saving or issue bank notes or bond. There are two limitations with these arrangements. First of all there is a liquidity constraint in how much capital each mortgage lender can raise in funding its mortgage needs. More importantly, there is a risk appetite issue in that holding the whole loan as an asset is deemed to have too much risk.

The creation of Fannie Mae in 1938 and the subsequent creation of the GSEs (described in Section 2.1.C.) was an important development. In the early 1980s another very important innovation revolutionalized the mortgage financing. That is the creation and dramatic development of the mortgage backed securities (MBS). Once again, Fannie Mae and Freddie Mac played a major role.

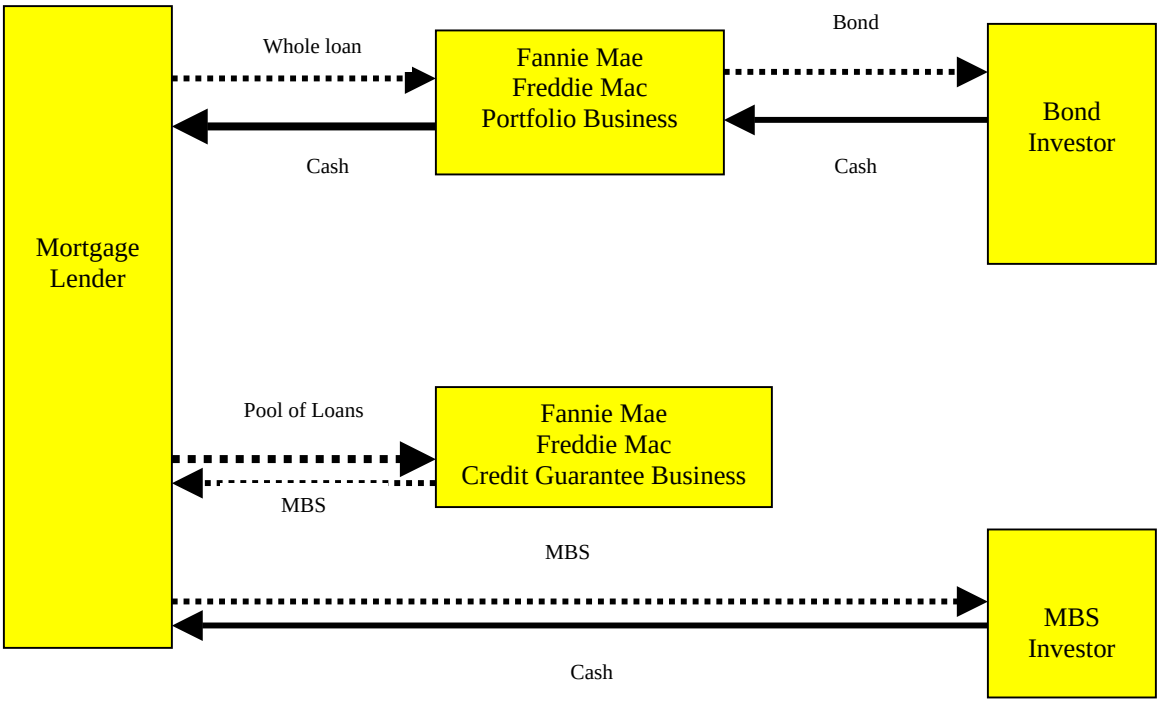
This is, in a nutshell, how MBS works. A lender delivers a pool of mortgages to Fannie Mae (or Freddie Mac). Fannie Mae issues a mortgage-backed security to the lender. Unlike selling the whole loan to Fannie Mae, the lender does not receive cash in this case. Instead, the lender swaps mortgage loans for a Fannie Mae issued mortgage-backed security and can then sell the mortgage-backed security for cash to investors through Wall Street dealers. The issuer of the mortgage-backed security, Fannie Mae, guarantees the timely payment of principal and interest to the investor (the holder of MBS) and in return receives a guaranty fee.

For example, a lender originates a pool of 6% mortgage loans and services the loans. When the lender delivers the pool of loans to Fannie Mae, the payment Fannie Mae receives will be 5.25% because the lender takes 0.75% as servicing fee. Fannie Mae issues a mortgage-backed security to the lender who can then sell it to the investor (say, a pension fund). Fannie Mae guarantees that the investor will receive timely payment of principal and interest, but it passes only 5% to the investor, charging a 0.25% as the guarantee fee. Fannie Mae takes the credit risk in the event of a default by the borrower and as compensation receives a guaranty fee. What the mortgage-backed security investor receives as a pass-through is the amount the borrower paid, minus the lender's servicing fee, minus the guarantee fee. By securitizing loans, Fannie Mae and Freddie Mac (and other players in the secondary mortgage market) replenish the supply of funds lenders have available for creating new mortgages.

MBSs are creative investment instrument. Individuals interested in investment of mortgages rarely purchase single loans from lenders. A whole loan carries both credit risk and interest rate risk, which is too risky and too unpredictable. By pooling many loans together, a future performance of a share of MBS is more predictable. If you buy only one loan, you future cash flow is dictated by what the borrower of that loan does. If you buy one percent of a 100-loan pool, you future cash flow is determined by the average of the 100 borrowers. Diversification makes your investment much safer and much more predictable. Nowadays, most MBSs are stripped and graded to serve the needs of a variety of investors.

Figure 2 below illustrates two lines of business of the two GSEs and their role as media in connecting investors to mortgage lenders in the secondary mortgage market.

Figure 2. Mortgage Financing Process



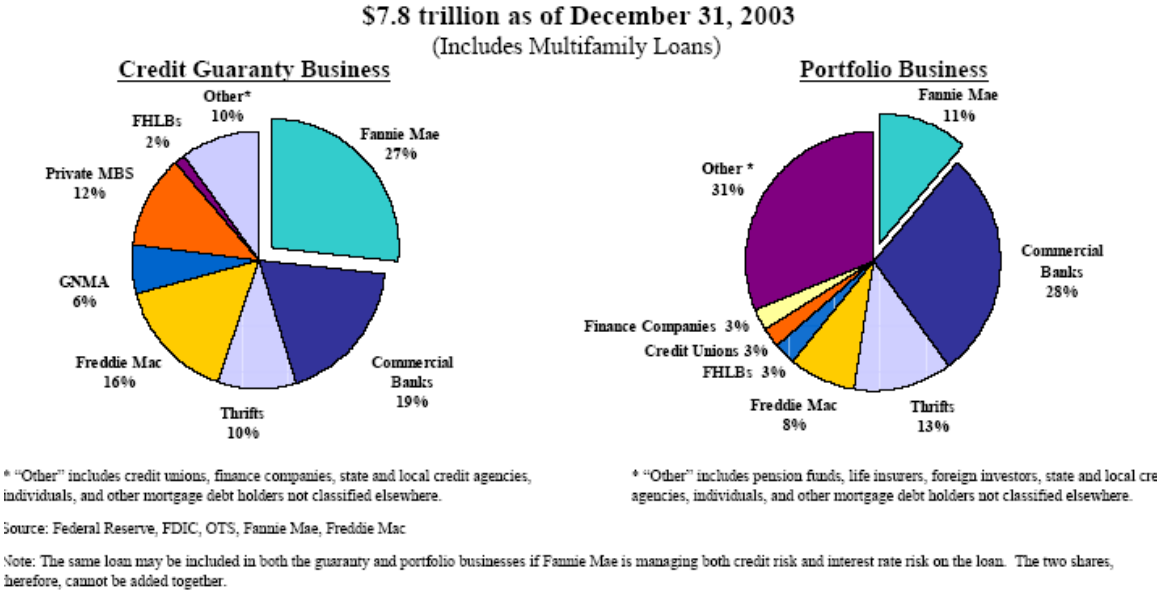
- As portfolio investors, the GSEs purchase (whole) mortgage loans, issue benchmark notes (bond) from the world capital market, and earn income primarily from the difference between yield on these mortgage assets and the cost of the debt and internal capital used to fund these assets.

- As MBS credit issuers, the GSEs receive pools of mortgage from mortgage lenders, package them as GSE guaranteed MBS, and receive income in terms of an insurance premium.

By supplying the market with securities to the investors, they increase the flow of funds into the mortgage market, and help drive down the mortgage rate for borrowers. It should note that, although relevant law and regulations prohibit the GSEs to conduct mortgage related business outside the US, the GSE do raise substantial capital from the world market. Investors from Japan, the EU, South Korea, and China provide a big proportion of Fannie Mae's debt and stock.

Figure 3 below decomposes the two lines of business by market participants. As of December 31, 2003, the two GSEs provided 43% of total mortgage guarantee and owned 19% of total mortgage outstanding.

Figure 3. Decomposition of Total Mortgage Debt Outstanding [7]



* "Other" includes credit unions, finance companies, state and local credit agencies, individuals, and other mortgage debt holders not classified elsewhere.

* "Other" includes pension funds, life insurers, foreign investors, state and local cre agencies, individuals, and other mortgage debt holders not classified elsewhere.

Source: Federal Reserve, FDIC, OTS, Fannie Mae, Freddie Mac

Note: The same loan may be included in both the guaranty and portfolio businesses if Fannie Mae is managing both credit risk and interest rate risk on the loan. The two shares, herefore, cannot be added together.

3. Using Consumer Credit in Mortgage Risk Modeling

This section discusses how consumer credit reporting and scoring are used in modeling mortgage risk.

3.1 Credit Report and Credit Scoring

A. Credit Bureaus and Credit Report

In the US there are currently three major credit-reporting agencies that gather, maintain, process, and sell information about consumer's credit history: Experian, Equifax and TransUnion.[8] Although these agencies are commonly called credit bureaus, they have nothing to do with government bureaucracy. Rather they are private companies.

For a small fee (ranges from free to just a few dollars), everybody can request a review of one's own credit information in the form of credit report. Credit report in the US is so taken for granted today. But it took many years of development and accumulation. When a consumer applies for any line of credit, rents an apartment, or even buys an auto insurance, the grantor typically orders the credit report about the consumer.

[7] Source: Fannie Mae Investor Relations (2004).

[8] Although many national lending institutions report consumer credit information to all three agencies, some small banks may only supply their information to one of the three agencies. Therefore there are small differences in what shows up in a consumer's credit report from the three credit bureaus. Other papers in this panel describe these in greater details.

A consumer credit report is a document that contains a factual record of the individual's credit payment history. An active account can be a charge account, a car loan, a student loan, or a home mortgage. As borrowers payback those credit accounts, lenders report the payment information to the credit bureaus. A credit report contains the following four broad areas of the information:

(1) Identifying information: name, current and previous addresses, social security number, year of birth, current and previous employers, spouse's name

(2) Credit Information on all accounts: Detail payment history about credit cards, installed loans (car loans, student loan, mortgage loan, etc.), any late payment, outstanding debt, and utilization ratio.

(3) Public records: bankruptcy, monetary judgments, or tax liens.

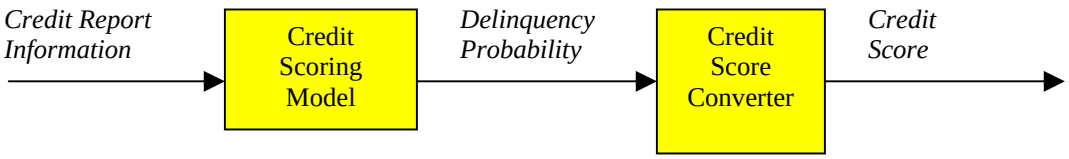
(4) Inquiries: Recent frequent inquiries of the one's credit reports can be a bad thing.

B. Generic Credit Scoring Method

There is detailed information involving dozens of variables in one's credit report. This rich information cannot be directly used in business application without being further summarized. Credit scoring uses statistical model to summarize of the credit information into a single index. The premise of the credit scoring method is that past performance is somewhat indicative to future credit worthiness.

The statistical model uses all the credit report fields to predict future delinquency or late payments.

Figure 4 Illustration of Credit Scoring System:



Since the most natural and direct measure of the status of a credit account is whether the account is active or is delinquent, a generic credit scoring model uses a vector of explanatory variables, X, to predict future delinquency, Y. Since Y is a binary or *Bernoulli variable*, it is conveniently coded as taking values either 0 or 1. The conditional mean of Y given X equals the conditional probability of Y=1 given X.

Different scoring models have different choice of vector X, different measure of bad account Y, and different specification of the conditional mean of Y given X. The most common specification is the logstic regression model that postulates

(2) $$E[Y|X] = P(Y=1|X) = \exp(X'\beta) / [1 + \exp(X'\beta)$$

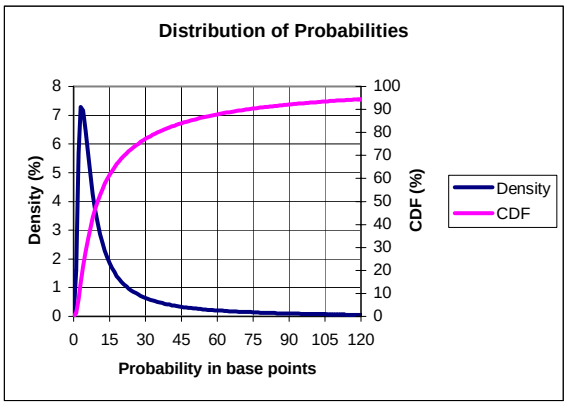
In (2) the conditional probability of Y=1 given the set of values in X is a function of X and a set of unknown parameters, β. The unknown parameters are estimated using statistical inference that best fit the historical data.[9]

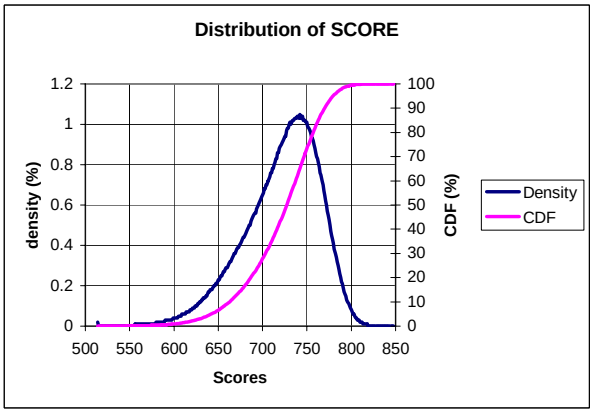
Once the model parameters, β, are estimated, the credit-scoring model can be used to predict the probability of future delinquency. This probability is typically asymmetrically distributed, skewed, and, by construction, ranged between 0 and 1. Therefore the credit scoring method contains another component that converts the predicted probabilities to a common score. Figure 4 above depicts the flowchart of a typical Credit Score System.

There are many competing credit scoring systems. By far the most well known today is the one developed by a company named Fair Isaac whose score is called FICO® score. FICO score is a number, usually in the range between 300 and 900. The higher the number the better the score. Overall a score of 650 or above is a sign of very good credit. People with higher credit score have better chance of obtaining quality loans at better interest rates. We will discuss how FICO scores are used in mortgage lending decisions later on.

Figure 5 below illustrates a typical distribution of the predicted delinquency probabilities and the distribution of the FICO Scores.

Figure 5. Distributions of Delinquency Probabilities and of FICO Type Scores





[9] An (2002) reviews logistic regression and many other popular statistical and econometric methods used for credit risk managers.

3.2 Consumer Credit Score and Mortgage Credit Risk

A. Risk Factors

Generic credit score measures the overall credit worthiness of a consumer. The credit risk of a mortgage, however, is determined by credit score and by many other factors specific to the mortgage. It is convenient to group the main mortgage risk factors into three categories:

- *Borrower Characteristics:*
  Credit Score such as FICO
  Debt to Income Ratio
  Asset servicing ratio
  Social Demographics

- *Loan Characteristics*:
  Loan-to-Value Ratio
  (Extra) Note Premium
  Mortgage Type (Fix Rate vs. Adjustable Rate)
  Loan Purpose (Purchase vs. Refinance)

- *Collateral Characteristics:*
  Property Type (such as manufactured homes)
  Occupancy (Investment home vs. owner-occupied)

It should be noticed that all these factors are *static* variables in the sense that they are observed and measured at the loan origination. As the borrower makes the monthly payments, the some of these factors change and the relative importance of risk factors also change.

B. Mortgage Risk Scoring Method

Not all the risk factors have the same impact on mortgage credit risk. Just like FICO is a comprehensive score representing overall credit worthiness of the borrower, one can use statistical model to summarize all the risk factors listed above and to arrive at a super mortgage score.

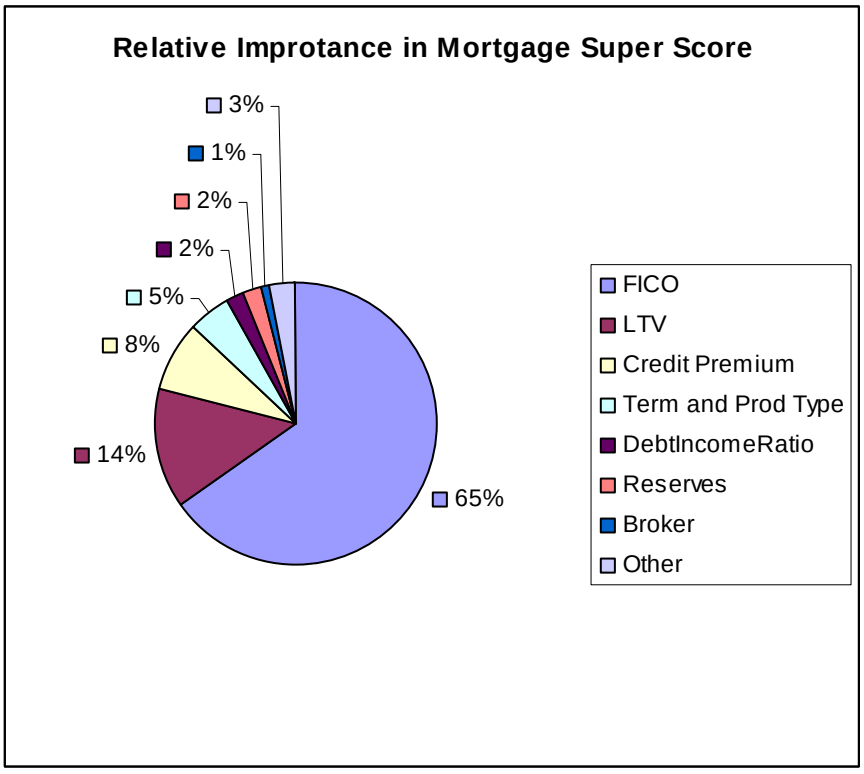
One way to do this is again to use logistic regression to regress a bad outcome on the set of chosen variables.

C. Relative Importance of Mortgage Risk Factors

Such a statistical scoring model can also be used to rank order the importance of each variable by computing the relative contribution of each of the risk factors. According to the analysis of variances, the total variation of the dependent variable can be divided into the part that are explained by the model and the unexplained part:

(3) $$V[Y] = V[\hat{Y}] + V[Y-\hat{Y}].$$

Figure 6 Relative Importances of Risk Factors in Mortgage Super Score[10]



For the logistic regression model, $\hat{Y} = \exp\{X'\hat{\beta}\}/(1+\exp\{X'\hat{\beta}\}) = \Lambda(X'\hat{\beta})$. Suppose, with out loss of generality, that X is a d-dimensional vector. Define for j=1, 2, …,d, partition X = (X^1, X^2, …, X^d). From the Delta method,

(4) $$V[\hat{Y}] \approx [\lambda(X'\hat{\beta})]^2 \bullet V[X'\hat{\beta}]$$

$$= [\lambda(X\hat{\beta})]^2 \left\{ \sum_{j=1}^{d} V[X^j \hat{\beta}^j] + 2\sum_{j<k} Cov[X^j \hat{\beta}^j, X^k \hat{\beta}^k] \right\}$$

where λ is the derivative Λ. Ignoring the sampling error in estimating β via $\hat{\beta}$, and equally distributing the correlation between any of the two variables, we can approximate the contribution of the j-th variable as proportional to

[10] Source: An, de Ritis and Rosenblatt (2003).

$$V[X^j\hat{\beta}^j] + \sum_{k\neq j} Cov[X^j\hat{\beta}^j, X^k\hat{\beta}^k]$$

Both of these terms can be easily estimated using sample averages. Using SAS, the following steps achieve this goal easily.

Step 1 Calculate **xb1$_i$ =** $X_i^1\hat{\beta}^1$**, xb2$_i$ =** $X_i^2\hat{\beta}^2$**,…, xbd$_i$ =** $X_i^d\hat{\beta}^d$ **for all observation i;**

Step 2 Calculate the Variance-Covariance Matrix using **Proc CORR cov;**

Step3 Calculate the **row sums** of the Variance-Covariance Matrix**.**

Figure 6 (pi-chart) illustrates a typically derived relative importance of various origination factors to early serious delinquency in a group of residential mortgages. The chart shows that "FICO" score contributes 65% of total variation of explainable mortgage delinquency; "Loan To Value Ratio" came in as a distant second that explains 14%. Credit Premium (extra note rate) registered as the third most important.

3.3. Modeling Total Risk of Mortgage

A. Prepayment Risk versus Credit Risk

A mortgage contract terminates either when the borrower defaults on the loan (by surrendering the collateral and walking away) or when s/he prepays the loan completely. From the mortgage investor point of view, these are the two types of risks embedded in mortgages: default risk and prepayment risk. In the US, a mortgage typically carries no prepayment penalty to the borrower. That means borrower can freely pay back at any time during the mortgage term.

A borrower would prepay for any (or a combination) of the following three reasons:

(1) The market mortgage interest rate has dropped substantially so that there is net financial gain, if the borrower applies for a new mortgage at the currently mortgage rate and pays back the old mortgage. This activity is called Rate Refinance.[11]

(2) The homeowner has accumulated a substantial home equity (the difference between the value of the house and the unpaid balance on the mortgage) and he/she wants to borrow a larger amount of money then the current unpaid balance. By borrowing more (from the new lender) the borrower can use the extra money for other purpose. This activity is called Cash-out Refinance.

[11] The net gain of a rate refinance for a borrower is the difference between the lifetime saving due to the lower interest and the one-time refinance costs. Thanks to the advancement of underwriting technology and standardization of mortgage underwriting, the closing cost of mortgage origination to the borrower has substantially reduced in recent years. As a consequence, it used to be a rule of thumb that a 2% rate drop would warrant a rate refinance. Now the threshold is only in the neighborhood of 0.5%.

(3) Due to the change in the economic and demographic conditions in the household (divorce or death in the family, more income, new job offer) etc, the homeowner decides to move out of the house (in order to buy a bigger or smaller house, to become a renter, to move to another area, etc.). Each mortgage is tied up to a particular collateral property. Selling the house implies the total unpaid balance has to be prepaid.

Mortgage prepayment is easier to understand. Understanding mortgage default is more difficult. According to the ruthless default hypothesis, a borrower would default if it perceived that the net benefit of default is positive. If the borrower thinks that due to a deep depreciation in the market value of the house he has a negative home equity, i.e, the market value of the house is less than the unpaid balance on the mortgage he would just walk away and surrender the property to the lender. In reality things might be more complicated than that.

(1) Not every borrower can know with certainty what the house is worth.

(2) The cost of default includes non-monetary terms loss such as psychological discomfort, difficulty in borrowing in the future, etc. These non-monetary costs vary cross people.

(3) Not every borrower with negative home equity would immediately default. One might as well wait until the future appreciation of housing market.

Apart from the common belief that defaults are mainly caused by negative home equity, many believe defaults might be directly triggered by a stressful event, such as a layoff from work, a divorce, etc.

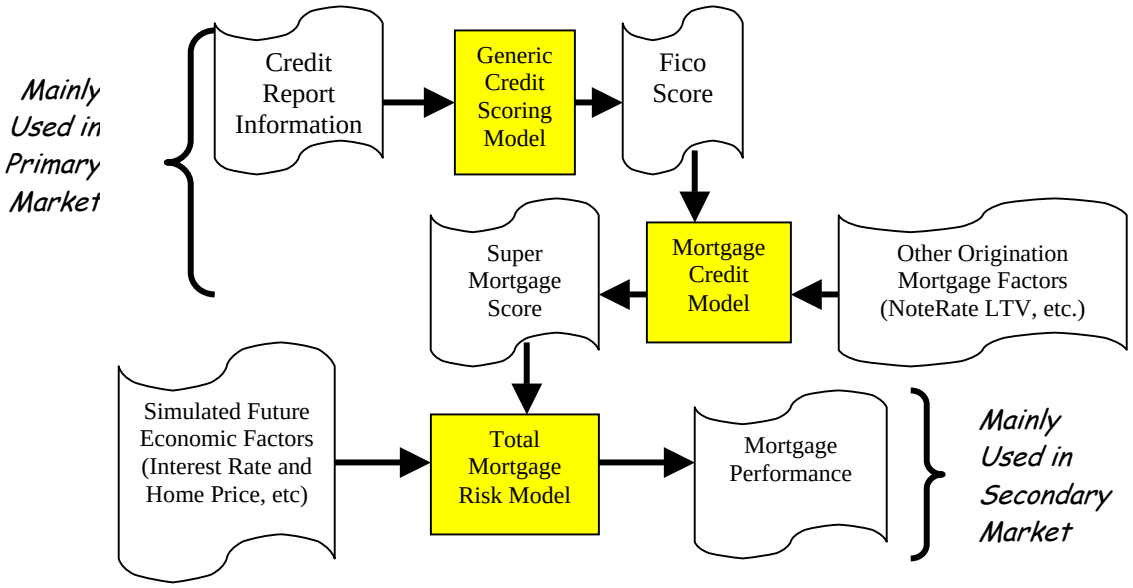
B. Competing Risks Modeling

Both prepayment and default are two options and decisions available to the borrower. Various statistical models have been suggested to represent the two decisions simultaneously. The most popular empirical model is the continuous-time, competing-risk model, popularized by a recent paper by Deng et al (2000). An (2004) recently pointed out an error in that paper. Since this model will be the most important core model of mortgage credit pricing and MBS valuation, in the Appendix I will explain the basic set up and clear up the error. The discussion in the remaining of this section, taken from An (2004), is rather technical in nature. Readers who do not care details can skip those materials on the first reading.

3.4 Summary

To summarize, in this section I discussed three credit models. The following chart depicts the their relationship.

Figure 7 Relationship among Three Credit Models



4. Using Consumer Credit in Mortgage Lending Decisions

4.1. Mortgage Underwriting: Approval of Mortgage Applications

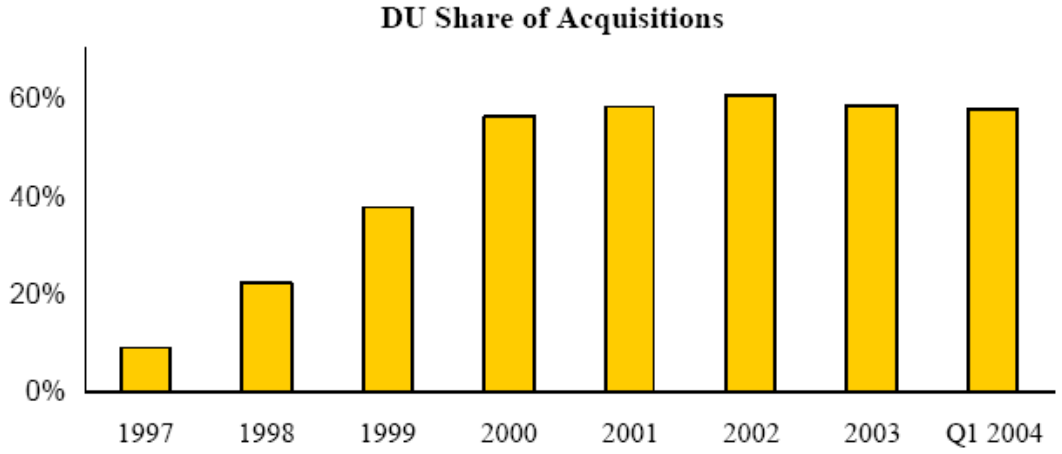
The most important mortgage lending decisions are made at the loan origination stage. It is for the underwriter to decide whether to approve or decline a mortgage application from an applicant.

There are two kind of errors associated with each of this underwriting decision: to approve a loan that cause larger than expected credit loss or to decline a potentially profitable loan application so that to loose the business opportunity. Super mortgage score provides a comprehensive index that rank orders credit risks of residential mortgages. Mortgage underwriter uses this score to determine a cut-off and use the cut-off to determine whether to approve or decline a loan application.

The fast advance of computing technology and telecommunication in 1990's brought about dramatic booming of e-business. In mortgage industry this is reflected in the adoption of automated underwriting paradigm. In the mid 1990's, both Fannie Mae and Freddie Mac developed their own automated underwriting tool (Desktop Underwriter® for the former, and Loan Prospector® from the latter).

Figure 8 Fannie Mae's Share of Loan Acquisition via Its Desktop Underwriter®[12]

[12] Source: Fannie Mae Investor Relations (2004).



- During Q1 2004, 1,719 lenders and 36,808 brokers chose our Desktop Underwriter (DU) or Desktop Originator (DO) systems. During the first quarter of 2004, 2.6 million loans were processed through DU.
- During Q1 2004, Fannie Mae processed 13.4 million loan submissions.
- The flexibility provided by this same technology enables lenders to expand the benefits of Fannie Mae financing to new market segments such as loans to credit-impaired borrowers, as well as to expand the market generally.

Compared to a human underwriter, automated underwriting tools have the following benefits:

- *Standardized and centralized underwriting policy*. Using an automated underwriting tool, a loan officer is able to logon to a national underwriting computer server; and the loan gets underwritten from a centralized and unified underwriting model. This eliminates the arbitrariness in mortgage underwriting. It should be point out that it was exactly because of Fannie Mae and Freddie Mac's adoption of DU and LP that made FICO an industrial standard as a measure for consumer's credit score around 1995-6.

- *Streamlined underwriting process.* Electronic file transfer saves time and money for the borrower and minimizes error in the process.

Because of these advantages, the market quickly embraced these automated underwriting tools. The following chart shows the Fannie Mae's DU shares of its business. The first pilot DU tool was introduced in 1996. By 2000, already close to 60% of the mortgages it acquired were DU underwritten.

4.2. Pricing in the Primary Mortgage Market: Note Rate

Everyone who shops at a local supermarket on a given day will typically pay the same price on the same good. This is because everybody is paying cash for the good. In another word, the supermarket is a spot market. A mortgage, however, is a future contract. Not only every loan is different – each loan is associated with a unique collateral properties

whose future value dynamics will be unique; the borrower has also different risk profile. Not every loan will be "bought' at the same price. Once a loan application is approved, the underwriter has to decide how much to charge the borrower for the mortgage. The price of the mortgage is reflected in the note rate for an FRM (and the margin for an ARM).

In the mortgage industry, lenders commonly use risk based pricing in the sense that the price is adjusted up or down to reflect the risk and/or the cost of transaction. For the same mortgage type, different borrowers can pay dramatically different interest rates. A prime mortgage with low credit risk and a sub-prime mortgage with high credit risk can be 3% apart in mortgage note rate.

The note rate that a lender charges to a borrower can be decomposed into two parts: the prevailing average market rate and a risk premium. The risk premium is typically a function of mortgage super score. From the pie chart in figure 6, FICO score counts 65% of the variation in mortgage super score. That is why in US people do care their credit report. Since credit history is a big part of the credit score, new immigrants, especially Hispanic immigrants, often get unfair treatment. They do not have time or do not realize the importance of establishing their credit history. In America, if you do not use credit cards, if you do not participate in the banking system, you will get punished. It is ironic, that the more you borrow, the easier you can borrow in the future, because your regular repayment of your previous borrowing establishes your credit record. That is the essence of consumer credit.

Lenders typically classify all the approved loans (loans whose mortgage supper score passes the pre-specified underwriting cut-off) into several risk groups and charge an average interest rate for all the loans in the same group. Mortgage interest rates are traditionally grouped into ticks that are 1/8 of one percent apart.

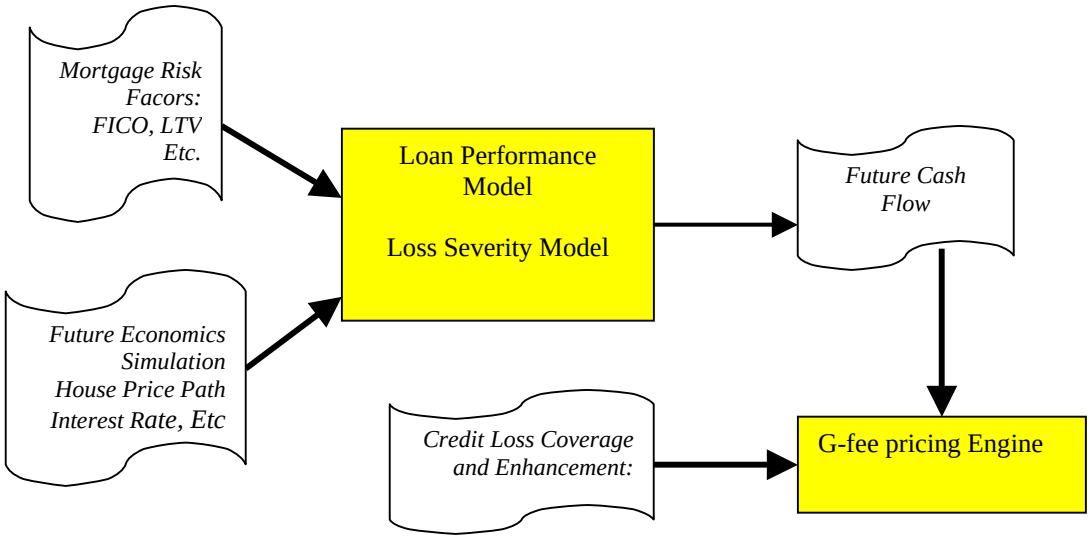
4.3 Pricing in the Secondary Mortgage Market: Guarantee Fee

Risk based pricing applies not only to the primary market wherein borrowers pay differentiated prices for their mortgages but also to the secondary mortgage market. For example MBS insurers such as Fannie Mae and Freddie Mac charge different guarantee fee for different mortgage loans they package.

Mortgage underwriting decision is more directly related to the super mortgage score, then mortgage guarantee fee pricing is much more complicated. It involves the forecasting all future cash flow and deciding essentially an actuarially fair risk premium.

As we mentioned earlier, a mortgage contract can terminate either by prepayment or by default. Prepayment simply stops the scheduled g-fee income stream. Default not only stops the income flow but often brings in credit loss. Everything in the future is uncertain, so those who provide mortgage guarantees have to be compensated for bearing those risks as well. Different loans have different PMI arrangements and other credit enhancements. All these influence the mortgage guarantee fee.

Figure 9 Guarantee Fee Pricing



5. Concluding Remarks

This paper has pursued two lines of discussion. First we studied how the US mortgage market works, especially how the development secondary mortgage market in general and the creation of Fannie Mae and Freddie Mac in particular helped to resolve the liquidity constraint and to share and distribute the risks embedded in residential mortgages. The secondary mortgage market links the primary mortgage market and the capital market by attracting those investors who traditionally have not invested in mortgages. In doing so the secondary market helps to accomplish the following objectives:

(1) It increases the availability of funds for mortgage lending by increasing the liquidity of mortgage investment and by allowing lenders to originate mortgages for sale and not just to keep for their own portfolio.

(2) The increased supply of funds for mortgage lending in turn helps drive mortgage rate down and thus benefit homebuyers.

(3) Investors and guarantors in the secondary market assume and manage mortgage-related credit and interest risks. This process both fostered and benefited from the standardization of loan origination and underwriting guidelines and procedures.

(4) The government sponsored enterprises in the secondary market help to serve the underserved sector in the society for their housing needs and to achieve public policy initiatives.

As the second line of discussion we studied the organic interaction between mortgage lending decisions and consumer credit reporting system. Credit worthiness of the potential borrower as summarized by a common credit score enters many mortgage risk models and is by far the most important risk factor in mortgages. Lenders use a super mortgage score to determine which loan application to approve and how much to charge for the mortgage. Mortgage risk and MBS guarantee companies (such as the GSEs) use the mortgage score and other factors to determine how much to charge for baring the mortgage risk.

US mortgage lending and mortgage finance industry has experienced many decades of developments. As China residential mortgage industry develops, it would be helpful to review the US experience and the current institutional, legal and regulatory arrangements. Key to this effort is to distinguish what aspects apply to China from what do not. To that end, it is crucial to think through all the pre-requisites of each and build those pre-requisites firsts. I would like to conclude with two comments.

1. Consumer credit reporting system played a crucial role in every facet of US mortgage industry. There are several difficulties for China to establish an advanced system very quickly. First of all, China, like many developing countries, is still pretty much a cash economy. Many transactions still use cash as predominant medium of exchange. Information on credit is hard to come by. Second, China by and large still does not have a national registry system, such as the social security registration in the US. Limited information on credit is difficult to match and accumulate over time. Third, China does not have fully functioning civil court systems that register public records on bankruptcy, delinquency, and judgment. Developments of all those need time.

   Mortgage lending and other consumer lending will be more efficient when the consumer credit reporting system become more established. However, if history is of any guidance, the US experience also points to the other direction. The standardized decision making in the mortgage industry also foster faster and healthier growth in consumer credit information gathering and reporting industry. The rapid development of residential mortgages in China offers an opportunity to create credit records and credit ratings for large numbers of Chinese consumers.

2. Housing requires money from banks and other investors. It is reasonable to assume that for some time in the future Chinese housing sector will have very limited access to the world market. In the US, one of the magic bullet has been the creation of mortgage-backed securities. With MBSs, banks do not need deposit to fund their mortgages. They simply make mortgages and sell them to securitizers such as the GSEs. How likely can China successfully create its own MBS?

   It should be noticed that investing directly in long-term, fixed-rate, fully amortizing, and prepayable mortgages is complicated. Baring and managing those the risks embedded in MBSs requires accurate credit models. Accurate models would not be available without effective measure of credit risk factors and rich

data on past performance on quality mortgages. Generating quality mortgages requires elaborate social and economic infrastructure: efficient legal mechanisms, healthy market for residential properties, and training of various professionals such as mortgage underwriters, property appraisers.

Given these concerns, a full-blown MBS market will probably not to occur over night. While waiting for these things to develop, China can start experiment with a "low-tech" system, similar to the recent experience in Mexco.

Appendix A Competing-Risk Model of Mortgage Performance

Let (T_1, T_2) be the two risk-specific (and latent) durations. Let $Y=\min\{T_1, T_2\}$ be the observable duration. Let R=1 if it is known that $Y=T_1$, R=2 if it is known that $Y=T_2$, and R=0 if both T_1 and T_2 are right-hand censored, in this case we observe some value c with the knowledge that $T_1>c$ and $T_2>c$. Let X be a vector of weakly exogenous covariates. Let $V=(V_1, V_2)$ be two unobserved heterogeneity factors. In loan termination terms, T_1 would be the duration until prepayment; T_2 would be the duration until default; Y would be the observed duration until the loan is terminated. If it is known that the loan is terminated due to prepayment, then R=1. If it is known that the loan is terminated due to default, then R=2. However, if by the time the survey ends, the loan of age c is still actively performing, then R=0 we say the both latent durations are right-hand censored at c.

A continuous-time competing-risks model under proportional hazard specification has the following three components:

Assumption 1 (**Conditional Independence**) Conditional on the observed and unobserved heterogeneity, (X, V), the two risk-specific durations T_1 and T_2 are independent.

Assumption 2 (Proportional Hazards) Conditional on (X, V)=(x, v), the hazard rates for T_1 and T_2 are, respectively,

(5) $$h_j(t|x, v)= \lambda_j(t) \exp\{x \beta_j+v_j\}, \qquad j=1,2.$$

A**ssumption 3 (Heterogeneity Distribution)** The heterogeneity vector (V_1, V_2) is independent from X, and is distributed with a bivariate distribution function $G(v_1, v_2)$ which is either

(a) $G(v_1, v_2)$ is degenerate, i.e., $P(V_1 =0, V_2 =0) =1$, or

(b) $G(v_1, v_2; \gamma)$ has a parametric form with parameter γ.

The parameters of primary interest are the regression coeffiecients $\beta_1$and β_2 together with possibly γ in the heterogeneity distribution. Following the tradition in single-risk setting due to the seminal work of Cox (1972), it is now customary to leave the two baseline hazard functions $\lambda_1(t)$ and $\lambda_2(t)$ in (1) unspecified to enhance the robustness of estimating $\beta_1$and β_2.

In the context of competing risks model, I will first assume, with out loss of generality, that the duration variable is grouped in two time intervals bounded by integers. Specifically,

Assumption 4 (Data Grouping) Every observation in the entire sample can be classified in the one of the following three types of grouping:

	Explanation of the Situation	Y Value	R Value	Knowledge of T_1 and T_2
Type P	A loan is prepaid in Period K_n[13]	$\in (K_n - 1, K_n]$	= 1	$T_1 \in (K_n - 1, K_n]$ & $T_2 > T_1$
Type D	A loan defaults in Period K_n	$\in (K_n - 1, K_n]$	= 2	$T_2 \in (K_n - 1, K_n]$ & $T_1 > T_2$
Type C	A loan is still performing at the time of observation in period K_n	$\in (K_n - 1, \infty)$	= 0	$T_1 > K_n - 1$ & $T_2 > K_n - 1$

These three types of data grouping are illustrated in Figure 10 (next page)

Proposition 1. *Without the parameterization of $\lambda_1(t)$ and $\lambda_2(t)$ the competing-risks model under proportional hazard specification is unidentified by grouped duration data.*

Notice that the non-identification for the competing-risk world is purely due to data grouping. It has nothing to do with whether or not the unobserved heterogeneity is present. This identification is also qualitatively different from the non-identification concept of Tsiatis (1975), as here the un-identification arises even under conditional independence between the two risks and enough variation of the X vector.

The direct implication of Proposition 1 is that it is necessary to make functional form assumption about the baseline hazards $\lambda_1(t)$ and $\lambda_2(t)$. Any meaningful inference comes from that assumption, and also hinges on that assumption.

One of the commonly used assumption is the piece-wise constant assumption, popularized after Han and Hausman (1990).

A**ssumption 5 (Piece-wise Constant Baseline Hazards)** For j=1,2, the baseline hazard function $\lambda_j(t)$ is piece-wise constant, that is, there exit constants such that

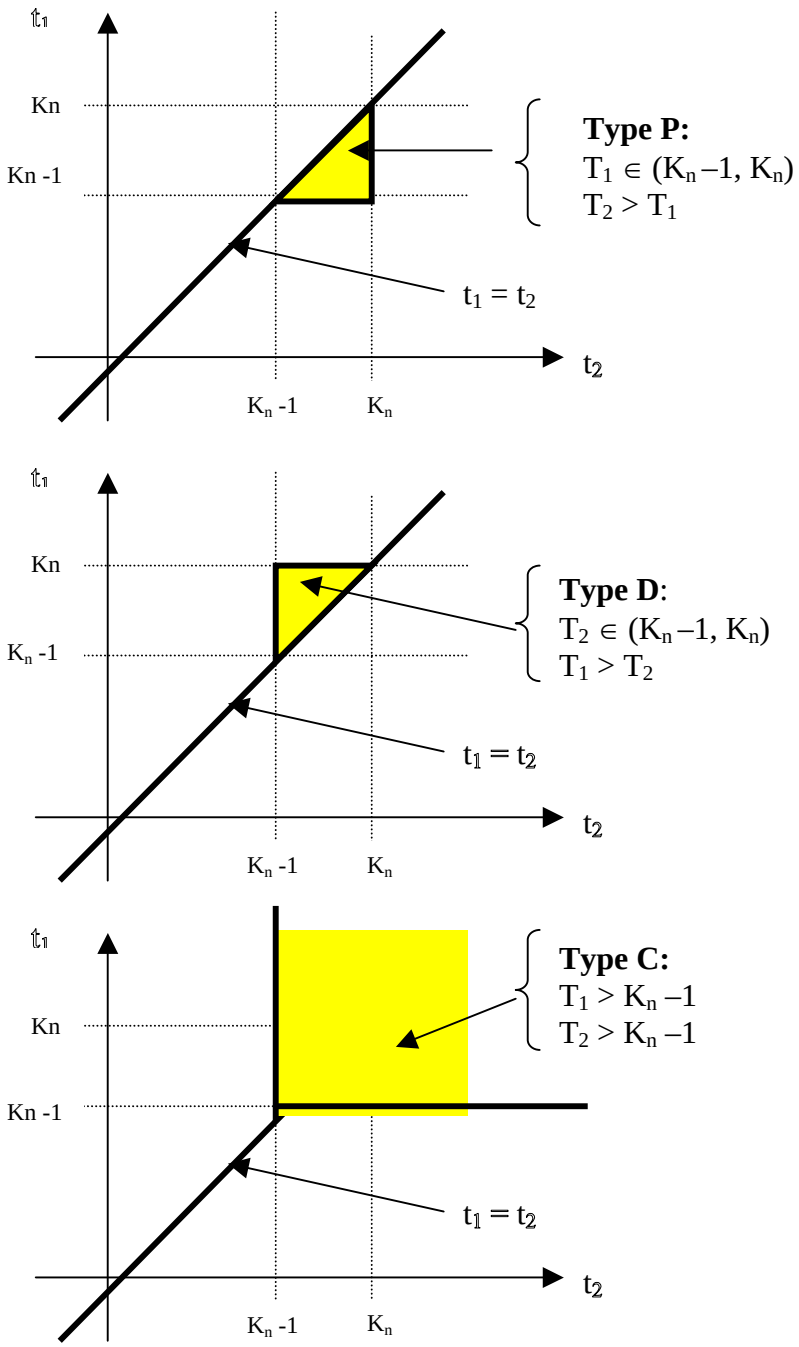
(6) $$\lambda_j(t) = \sum_{k=1}^{M} \alpha_{jk} 1_{t \in [k-1,k)}, \qquad j = 1,2,$$

where M is the total number of the distinct integers in the set $\{K_n\}$.

Under Assumption 5, the two integrated baseline hazard functions are *piece-wise linear* with interval-specific slopes α_{jk}.

13 Our convention is to name the interval (0, 1] the first period, the interval (1, 2] the second period, and so on.

Figure 10 Three Types of Grouped Duration Data



Using the notation given above, for each individual n in the sample we have the following information (X_n, K_n, R_n), whereby the value of R_n corresponds to the whether n belongs to Type P, Type D, or Type C. Notice that the heterogeneity vector (V_1, V_2) is unobserved.

With the above set up, An (2004) first show that the model is fundamentally unidentified. That is,

Proposition 2. Under Assumptions 1-5, the integral has an analytical expression, that is,

(7)
$$\int_{k-1}^{k} \lambda_1(t)\phi_{1n} \exp\{-\Lambda_1(t)\phi_{1n} - \Lambda_2(t)\phi_{2n}\}dt$$

$$= \frac{\alpha_{1k}\phi_{1n}}{\alpha_{1k}\phi_{1n} + \alpha_{2k}\phi_{2n}} \exp\{-\Lambda_1(K_n - 1)\phi_{1n} - \Lambda_2(K_n - 1)\phi_{2n}\}[1 - \exp\{-\alpha_{1k}\phi_{1n} - \alpha_{2k}\phi_{2n}\}].$$

The result is proved by simple algebra. Because under Assumption 5,

$$\int_{k-1}^{k} \lambda_1(t)\phi_{1n} \exp\{-\Lambda_1(t)\phi_{1n} - \Lambda_2(t)\phi_{2n}\}dt$$
$$= \int_{k-1}^{k} \alpha_{1k}\phi_{1n} \exp\{-\{\Lambda_1(K_n - 1) + \alpha_{1k}[t - (K_n - 1)]\}\phi_{1n} - \{\Lambda_2(K_n - 1) + \alpha_{2k}[t - (K_n - 1)]\}\phi_{2n}\}dt$$

To gain intuition of the above expression, denote

$$\theta_n = \frac{\alpha_{1k}\phi_{1n}}{\alpha_{1k}\phi_{1n} + \alpha_{2k}\phi_{2n}}.$$

Notice that under the Assumption 5, probability that the duration ends in interval $[K_n\text{-}1, K_n)$ conditional on (X_n, V) is

$$\Pr(K_n - 1 < Y_n \le K_n | X_n, V)$$
$$= \Pr(K_n - 1 < Y_n | X_n, V) - \Pr(K_n < Y_n | X_n, V)$$
$$= \exp\{-\Lambda_1(K_n - 1)\phi_{1n} - \Lambda_2(K_n - 1)\phi_{2n}\}[1 - \exp\{-\alpha_{1k}\phi_{1n} - \alpha_{2k}\phi_{2n}\}].$$

It is clear that Assumption 5 calls for a division of this probability mass according to the weights θ_n and $1 - \theta_n$ respectively.

McCall (1996) proposes an ad hoc approximation of the likelihood contribution of a Type P or Type D observation by essentially fixing $\theta_n = ½$ for all n. The corresponding formula under McCall (1996) is

$$\Pr(K_n - 1 < Y_n \le K_n | X_n, V)$$
$$= 0.5 \exp\{-\Lambda_1(K_n - 1)\phi_{1n} - \Lambda_2(K_n - 1)\phi_{2n}\}[1 - \exp\{-\alpha_{1k}\phi_{1n} - \alpha_{2k}\phi_{2n}\}].$$

In recent papers on loan performance models, Deng *et al* (2000), Ciochetti *et al*. 2001 and Ambrose and LaCour-Little 2001 for example, all adopt McCall's formula explicitly with their piece-wise constant assumption of the baseline hazards.

(1) In mortgage termination models, compared with prepayments, loan default is an extremely rare event. It is well known that default hazard rate is only a tiny fraction (1/50, say) of the prepayment hazard rate. In this case, 50-50 split of the probability is way is quite inaccurate.

(2) According to Proposition 2, the split ratio θ_n is individual specific, therefore cannot be fixed once for all for all observations.

Notice also that under Assumption 5, the joint survivor function, $S(K_n,K_n|X, V)$, depends on the baseline hazards only through the 2M discrete values of the integrated baseline hazards. Define

$$\rho_{jk} = \log[\Lambda_j(K_n) - (\Lambda_j(K_n-1)],$$

as the logarithm consecutive increments of Λ_j from k-1 to k. With this parameterization, the full parameter vector is

$$\delta = (\beta_1, \beta_2, \rho_{11}, \rho_{12,\ldots} \rho_{1M}, \rho_{21}, \rho_{22,\ldots,} \rho_{2M}, \gamma).$$

Estimation of δ can be carried out by maximizing the sample log likelihood function. The optimization routine depends on how the heterogeneity distribution is specified. The most convenient case is when the heterogeneity distribution.

The most convenient way to specify the heterogeneity distribution is the two-dimensional discrete distribution.

The two propositions in the Appendix meant to deliver two main messages. First, the models with nonparametric baseline hazards are fundamentally unidentifiable with grouped duration data. When a competing-risks model is fit with grouped duration data, any meaningful inference has to stem from and hinge on parametric assumption of the baseline hazard. Second, under parametric assumption such as the piece-wise linear baseline hazards, the sample likelihood function has explicit analytical functional form. Direct estimation using the full likelihood function is feasible and easy. Under this assumption, approximation of the likelihood function is no longer necessary. Specifically, when the two risks are very different in hazard rate, the folk approximation using a 50-50 split can be very damaging.

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Brief Bio of the Author

Mark An is Director of Economics Research at Fannie Mae, the largest US mortgage finance company, that provides credit guarantee to over US $2 trillion residential mortgages. At Fannie Mae Mark has led the research efforts in the creation of acquisition credit index (ACI®, patent application pending) that has become the common currency of all credit risk models in the company, in the revamp of the loan termination models (LTM®) that underlie the guaranty fee pricing framework, and in the incarnation of the comp analysis and statistical tests (CAST®, patent application pending) that is used in monitoring of credit performance of loan segments. Since January 2003 he has been leading a team working on a comprehensive project to enhance automated property valuation models (AVM).
Before joining Fannie Mae in 2000, he was on the faculty at Duke University. He held visiting or adjunct professorship at Johns Hopkins University and University of Aarhus, Denmark.

Mark received his Ph.D in economics from Cornell University in 1993. His research areas are econometrics and applied microeconomics. He has published more than a dozen papers in top economics journals including *The Review of Economics and Statistics, Journal of Economic Theory, Journal of Business and Economic Statistics, American Journal of Agricultural Economics, Journal of Applied Econometrics, The Econometrics Journal, Journal of Development Economics, and Journal of Evolutionary Economics.*