An Evaluation of Adjustable Rate Mortgage Risk

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Abstract

An Evaluation of Adjustable Rate Mortgage Risk

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Introduction and Purpose

Home ownership has long been an objective of public policy. In the past the primary method of financing a home has been the thirty-year fixed rate mortgage. This instrument served borrowers and lenders very well for many years. In the 1970s, increases in the inflation rate led to record high long term interest rates. This caused severe problems for originators of the traditional fixed rate mortgage. As a result of these difficulties, government regulatory agencies eliminated many of the constraints that had been placed upon home mortgage design. A new class of mortgage instruments known as Adjustable Rate Mortgages (ARMs) are the result of the relaxed mortgage design regulations. The key charicteristic of ARMs is that the rate of interest charged the borrower varies over the life of the mortgage. The variance in the contract rate of the mortgage is reflected in changes in the payment, balance or term of the mortgage. The purpose of this dissertation is to develop a model of rational mortgage risks and use the model to examine the impact of adjustable payment, term and balance mortgages on mortgage risks.

The model of mortgage risks consists of a set of Potential Losses. Potential Losses measure the expected value of a loss to a lender on the date of the mortgage origination associated with a set of specific rational triggering events associated with each type of risk. The formulation of the triggering events is based on the results of studies of the determinants of mortgage risks and various theories on mortgage risks.

Methodology

Interest rate, housing prices and family income data was collected monthly from January 1971 to December 1983. This data was transformed into series that were not significantly different from normal. This information served to govern the stochastic processes of each series as they were simulated to provide the disturbance terms of a Monte-Carlo experiment. The form of the experiment was:

$$PL_n = MD_m + TE_n + DT$$

where PL_n is the n^{th} Potential Loss, MD_m is mortgage design m, TE_n are the triggering events of Potential Loss n and DT are the disturbance terms.

Fourteen mortgage designs are examined under two sets of disturbance terms. The mortgage designs consist of the fixed rate mortgage, the basic adjustable payment, term and balance, and the adjustable payment with a limitation on the volatility of the monthly payment. Each of the adjustable rate mortgages are given one, three and

five year adjustment intervals. The mortgage designs evaluated allow conclusions to be drawn about the impact of the adjustment mechanisms, adjustment intervals and mortgage terms upon the mortgage risks.

Results

The results of the Monte Carlo experiment reveals that mortgage design has a significant impact on mortgage risks. Further, many of the design components that reduce one form of risk increase another. The mortgage provisions can be described as enhancing mortgage parameter stability or decreasing mortgage parameter stability. Those provisions that increase the stability of the mortgage contract rate cause increases in residual interest rate or market risk, and decreases in delinquency and default risks. Provisions that cause increases in the instability of the contract rate enhance default and delinquency risk but reduce market risk. Premature termination due to rational mortgage call risk is decreased by positive prepayment penalties and increased by longer adjustment intervals. Payment limitations decrease delinquency risk.

The implication of the findings can be summarized in three statements. Risk averse mortgage designers should include limitations on the ability of the monthly payment of any mortgage to increase. A per period payment cap of 7.5%, decreases risk significantly and increases the expected return on one year adjustable payment mortgages. Longer adjustment intervals increase market risk significantly, but can be used

to reduce exposure to default and delinquency risks with an increase in the expected return. The final conclusion is that prepayment penalties must be part of the design of mortgage instruments. The adjustable rate mortgages examined have a significant exposure to prepayment risk and this risk can be decreased by the inclusion of a prepayment penalty in the mortgage design.

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CHAPTER I

INTRODUCTION

Home ownership has long been an objective of public policy. In the past the primary method of financing a home has been a thirty-year fixed rate mortgage. This instrument served borrowers and lenders very well for many years. In the 1970s, however increases in the inflation rate led to record high long term interest rates. This caused severe problems for originators of the traditional fixed rate mortgage. As a result of these difficulties, government regulatory agencies eliminated many of the constraints that had been placed upon home mortgage design.

In April of 1981, the Federal Home Loan Bank Board adopted an extremely liberal set of rules governing the design of mortgage instruments.[1] Mortgage instruments developed under these guidelines are classified as Adjustable Mortgage Loans (AMLs). The key characteristic of AMLs is that the rate of interest charged the borrower varies over the life of the loan. The acceptance of AMLs by borrowers and lenders has been amazing. Adjustable Mortgage Loans accounted for one and one tenth percent of all single family loans closed in January of 1981. Twelve months later, Adjustable Rate Mortgage loans comprised 37.8 percent of all mortgages closed. By the end of 1983 Adjustable Rate Mortgages accounted for sixty percent of new mortgage originations[2].

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[1] Federal Home Loan Bank Board. "Adjustable Mortgage Loan Instruments. 12 CFR Part 545." April 30, 1981.

[2] Federal Home Loan Bank Board Mortgage Interest Rate Survey.

Part of the spectacular growth of Adjustable Mortgage Loans can be traced to the large number of different designs available to borrowers and lenders. The variety of mortgage designs available has created a situation in which there is an AML that meets the needs of practically all borrowers and lenders. The number of different instruments available is demonstrated by the purchase of one hundred and twenty different Adjustable Mortgage Loan designs by the Federal National Mortgage Association between January and May of 1983.[3]

There is every reason to believe that the number of different mortgage designs will increase over the coming years. In fact, it has been estimated that there is enough dollar volume in mortgage instruments to support efficent markets in up to five hundred different mortgage designs.[4] The large number of different designs available on the market has created a new problem for borrowers and lenders. Namely, how do the new mortgage designs impact traditional mortgage risks. It is the purpose of this dissertation to examine traditional mortgage risks and how they are influenced by various mortgage provisions that are commonly found in Adjustable Mortgage Loan contracts. The mortgage provisions to be examined are the building blocks of a subset of AMLs known as Adjustable Rate Mortgages (ARMs). The building blocks of ARMs

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[3] Maxwell, David. Remarks made at the American Bankers Association Conference on Secondary Markets. May 2, 1985.

[4] Guttentag, Jack M. "Solving the Mortgage Menu Problem," Paper presented at the American Real Estate and Urban Economics Association Mid-Year Meeting, May 31, 1983, Washington D.C.

consist of three methods by which a mortgage instrument responds to changes in its contract rate. The methods are variable payment, variable balance, and variable term. Variable payment mortgages adjust the monthly mortgage payment to reflect changes in the mortgage's contract interest rate. Variable balance mortgages have a constant payment, but alter the amount of the payment that is used to reduce the remaining balance on the mortgage. In some cases the monthly payment may be insufficient to meet the interest obligation of the mortgage. When this occurs, the mortgage balance is increased by the deficiency.[5]

Variable term mortgages also have a constant monthly mortgage payment. They adjust to changes in the contract rate of interest by changing the maturity date of the mortgage. If the contract rate rises, the maturity is lengthened or shortened so that the remaining balance is fully amortized at the contract rate of interest using the monthly payment. The mortgage must mature within four hundred and eighty months of its origination date. If this cannot be achieved using the original monthly payment, negative amortization accumulates. Chapter Two discusses the Adjustable Mortgage Loan regulations and the mechanics of Adjustable Rate Mortgages.

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[5] Increases in the remaining balance of a mortgage due to the monthly payment being less than the required interest payment is negative amortization.

The traditional mortgage risks include termination,[6] default, delinquency, and market.[7] Default and delinquency have been the subject of a great number of studies. Virtually all of the studies used fixed rate mortgage data and arrived at the same conclusions regarding the determinants of default and delinquency. Termination and market risk have not been the subject of as many studies because these risks are relatively minor in periods of stable interest rates. The primary motivator of market and termination risks is interest rate volatility. When interest rates are stable, borrower's have little reason to call or put their mortgages and the value of the mortgage on secondary markets approximates the remaining balance. The volatility of interest rates increased dramatically in the 1970s, creating increased interest in mortgage termination and market risks. Chapter Three reviews the mortgage risk literature as it applies to both fixed and adjustable rate mortgages.

The methodology used to measure the impact of various mortgage provisions upon the traditional mortgage risks consists of three steps. The first is the development of a model that estimates the level of risk exposure associated with a mortgage design. This is accomplished by defining a set of conditions that must exsist prior to a risk becoming a loss, and by developing a model to measure the size of a potential loss

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[6] Termination risk is restricted to deviations from the expected termination date of the instrument caused by economic mortgage calls and puts.

[7] Market risk is the risk associated with losses in the market value of a mortgage due to changes in the market required rate of return.

associated with a particular mortgage risk. In Chapter Four, the necessary conditions and potential loss measures for each mortgage risk are combined to form the Potential Loss model.

The second step in the method of examination is the implementation of the Potential Loss models. This is achieved by using Monte Carlo experimentation. The Monte Carlo technique is chosen for two reasons. First, there is not a long enough history associated with Adjustable Mortgage Loans to allow the use of ex-post data. Second, the Monte Carlo method allows mortgage provisions to be examined in isolation. This implies that the impact of a particular mortgage provision upon mortgage risks can be estimated without interference from other mortgage provisions. The Monte Carlo simulation generates Potential Loss data for each of the mortgage designs examined. The final step is to statistically analyze the Potential Loss data from the various mortgage designs. The results are used to rationally evaluate the benefits and costs associated with the mortgage provisions. Chapter Five discusses the Monte Carlo experiment and Chapter Six and Seven discuss results and conclusions.

Chapter II

Adjustable Mortgage Loan Regulations and ARMs

On April 30, 1980, the Federal Home Loan Bank Board adopted regulations allowing federally chartered savings and loans to design and originate mortgages referred to as Adjustable Mortgage Loans (AMLs).[8] The major difference between the new instruments and the traditional fixed rate mortgage is that AMLs are allowed to have a variable amortization or contract rate. The new regulations imposed few restrictions on the form and design of these instruments. As a result there have been a large number of instruments proposed and originated by various savings and loans. The following guidelines represent the only restrictions imposed on mortgage designers:

> 1. The index used to set the amortization rate must be readily verifiable and not under the influence of the mortgager writer (i.e. 6 month Treasury Bills).
>
> 2. If negative amortization occurs the instrument must contain a catch-up payment adjustment at least every five years. The catch-up adjusts the payment using the current interest rate so that the entire balance is amortized by the maturity date of the instrument (A maximum of 40 years from the origination date).

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[8] Federal Home Loan Bank Board. "Adjustable Mortgage Loan Instruments. 12 CFR Part 545." April 30, 1981.

3. A decline in the chosen interest rate index must be reflected in the amortization rate of the mortgage at the chosen adjustment interval. Increases in the index interest rate are reflected in the amortization rate at the discretion of the lender.

4. No fees may be charged for administrative costs associated with the adjustments to the mortgage.

5. Prepayment penalties are only allowed on fixed rate mortgages.

6. Borrowers must be notified at least 30 days and not more than 45 days from the effective date of a change in the payment or amortization rate.

7. Amortization rate adjustments can occur no more frequently than monthly.

8. The mortgage must be fully amortized within 40 years.

9. Full disclosure must be made at the time of the loan application. Disclosure must include: basic information on AMLs, the specific features of the AML being offered and an example of how the AML being offered would work.

Under the above guidelines it is apparent that almost any instrument that is marketable could be introduced as a viable method of financing a home. These regulations provide enough design freedom that the potential number of mortgage instruments is virtually infinite. The number of different instruments that are actually developed and actively traded

must remain under five hundred if each is to be traded efficiently.[9] The nature of the five hundred will be a function of borrower and lender attitudes toward the various available mortgage provisions.

The possible provisions can be separated into two categories: mandatory and optional. The mandatory provisions are those that name the related interest rate index, defines the relationship between the index and the contract rate, specifies how the instrument responds to changes in the index rate, and establishes the adjustment interval. The optional provisions place restrictions on the adjustment mechanism, contract rate, contract rate adjustments, and all other clauses.

The contract rate of all adjustable rate mortgages is a function of a specified interest rate index. The pattern of change of the specified interest rate index directly influences the pattern of change of the adjustable rate mortgage's contract rate. If the index is volatile, the contract rate will be volatile. If the index is stationary, the contract rate will be stationary. Historically the variance of the yields on short term securites has been greater than the variance of long term security yields. According to the AML regulations any index used to calculate a mortgage contract rate must be readily verifiable and not under the influence of the lender. This has lead to a list of recommended indices for use in AML designs. The most commonly used yield series are: three and six month treasury bills; and one, three and five

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[9] Guttentag, Jack M. "Solving the Mortgage Menu Problem," Paper presented at the American Real Estate and Urban Economics Association Mid-Year Meeting, May 31, 1983, Washington D.C. Pg.5.

year adjusted maturity treasury notes. Less commonly used, but recommended include the cost of funds for each of the Federal Home Loan Bank Board Districts, and the national cost of funds for the Federal Home Loan Bank Board. The most volatile of these series is the three month treasuries, followed by the six month and then the treasury notes in accord with their maturity. The least volatile are the cost of funds series of the Federal Home Loan Banks. Other interest rate series have been proposed and used in AML designs, but the above are the the most common by a wide margin.

There are two common methods of relating the selected index to the instrument's contract rate. The first is to use the index as an absolute base to which a premium is added to determine the contract rate. The equation is:

$$R_{ct} = R_{it} + P$$

where R_{ct} is the contract rate in period t, R_{it} is the index rate in period t and P is the premium. The contract rate varies by the same absolute amount as the index rate. The second method of calculating the contract rate is to use a percentage change approach. The equation is:

$$R_{ct} = R_{ct-1} * (R_{it} / R_{it-1})$$

where R_{ct} is the contract rate in period t, R_{ct-1} is the previous contract rate, R_{it} is the index rate in period t, R_{it-1} is the index rate at the prior adjustment interval. Under this method the contract rate changes by the same percentage as the index rate. Under both methods the movement of the index rate is reflected in the contract rate. This implies that the volatility of the contract rate is directly

related to the volatility of the index.

The three basic mechanisms used to adjust the mortgage to changes in the contract rate are: varying the payment, the balance, and the term to maturity. These response mechanisms are used alone and in conjunction with each other. The variable payment mechanism requires the payment of the mortgage to be changed to reflect the current contract rate. At each adjustment period a new monthly payment is calculated using the following formula:

$$PAY_t = BAL_t * 1/[(1-1/(1+r)^{n-t})/r]$$

where: PAY_t is the monthly payment until the next adjustment period, BAL_t is the balance remaining on the mortgage in month t; t is the number of months the mortgage has been outstanding, n is the total number of months the mortgage can be outstanding, and r is the new monthly contract rate. If the contract rate rises, the monthly payment increases. If the contract rate falls the monthly payment decreases. At each adjustment period the monthly payment changes so that the remaining balance is fully amortized by the termination date using the new contract rate.

Variable balance mortgages respond to changes in the contract rate by altering the proportion of the monthly payment that is attributed to principal reduction. The monthly payment remains constant, but the remaining balance does not follow a normal amortization pattern. The balance is adjusted each month by the difference between the monthly payment and the required monthly interest payment using the current

contract rate. Mathematically the balance changes by:

$$B_c = P - r_t * B_t$$

where; B_c is the change in the mortgage balance, r_t is the contract rate in period t, B_t is the remaining balance in period t and P is the monthly payment calculated by:

$$P = B_o / [1-1/(1+r_o)^n] / r_o$$

where; B_o is the balance of the mortgage at origination, r_o is the monthly contract rate at origination, and n is the number of months to maturity. The contract rate can influence the amortization pattern of the mortgage balance in three ways. If the contract rate in any period is lower than the origination contract rate the remaining balance amortizes at a faster rate. If the contract rate remains below the origination rate the mortgage is paid off prior to its termination date. If the new contract rate is higher than the origination contract rate there are two possible effects. If the increase in the rate is minor, the amortization of the balance slows, but the balance continues to decline. If the rate change is substantial, the remaining balance can increase each month. A growing balance is referred to as negative amortization. It can only occur if the monthly payment is not high enough to meet the monthly interest obligation. For example, if the remaining balance is $50,000,the current contract rate is one percent per month and the monthly payment is $450.00, the mortgage balance will increase by $50.00 in the first month. This increase causes interest obligation to increase to $500.50. The next payment, assuming no change in payment amount or contract rate is $50.50 less than the interest

obligation. Therefore, $50.50 is added to the remaining balance. As time passes the remaining balance grows and so does the monthly addition to the remaining balance. It is clear that without changes in the mortgage's parameters, the balance cannot be reduced and the mortgage cannot be terminated successfully.

The AML regulations contain a provision to eliminate this potential problem. Under the regulations, any mortgage instrument that allows negative amortization must adjust the monthly payment every five years in a manner that causes the remaining balance to be fully amortized at the current contract rate within four hundred and eighty months of the mortgage origination date. In other words, all variable balance loans contain a mandatory variable payment feature that has a five year adjustment interval.

The variable term mortgage responds to changes in the contract rate by varying the mortgage termination date. The length of time the life of the mortgage is extended is determined by an iterative process. The mortgage payment is established at origination using the following formula:

$$P = B \,/\, [\, 1 - (1/(1+r_o)^{n})\,]/r_o$$

where: P is the monthly payment, B is the mortgage balance, r_o is the contract rate at origination, and n is the initial mortgage termination date. At each adjustment period the new contract rate is established and the monthly payment required to fully amortize the remaining balance by

the termination date is calculated using the following formula:

$$P_n = B_t / [\, 1 - (1 / (1 + r_t)^m) / r_t \,]$$

where: P_n is the new monthly payment, B_t is the remaining balance in period t, r_t is the contract rate in period t, m is the number of months remaining until termination. If this payment is smaller than the mortgage payment calculated at origination, the length of time required to pay off the mortgage is decreased. If this condition persists the mortgage balance reaches zero prior to the initial termination date. If the newly calculated monthly payment is larger than the origination monthly payment, the original termination date is increased until the length of the mortgage from origination to termination reaches four hundred and eighty months or the newly calculated payment is less than the origination payment. Note that the actual monthly payment made by the borrower does not change.

The contract rates of adjustable rate mortgages do not respond to every change in the related index. Instead they adjust to the related index rate at predetermined points in time. Usually these points in time are evenly spaced, but there is no requirement that they be evenly spaced. Rate adjustment periods are normally of the same length as the maturity of the interest rate index. If an instrument's contract rate is a function of the yield on six month treasury bills, its adjustment interval is normally six months in length. It is possible to design an instrument that has an adjustment interval that is longer or shorter than the maturity of the related index. For example, an instrument may have an adjustment interval of six months and a contract rate that is a

function of the yield on one year treasury notes. The length of the adjustment interval can range from one month to four hundred and eighty months, the maximum life of a mortgage instrument. It normally ranges between six months and five years. The selection of an adjustment interval has a direct influence over the volatility of the mortgage's contract rate and all related parameters.

Many mortgages are designed with limitations placed upon the ability of the instrument's parameters to adjust to changes in the related index rate. These limitations restrict the adjustment mechanism, the contract rate, and changes in the contract rate. They are used alone and in concert with each other. The most widely used limitation is the payment cap. Payment caps have two forms, lifetime and adjustment. Lifetime payment caps restrict the monthly payment to a set dollar amount based upon the monthly payment calculated at origination. If the origination payment is $500.00 and the lifetime payment cap is ten percent, the maximum monthly payment is $550.00. If the contract rate increases to the extent that the monthly payment should be $600.00, the borrower will only pay $550.00. The difference is usually reflected by negative or slowed amortization of the balance. Payment caps are also expressed as maximum changes. If a payment cap states the maximum change (increase) in the monthly payment is restricted to five per cent per adjustment interval and the contract rate implies an increase in the monthly payment of ten percent, the new monthly payment is limited to one hundred and five percent of the old. Again the difference between the actual monthly payment and the payment implied by the contract rate

is reflected in the amortization pattern.

Many instruments limit the amount of negative amortization that is allowed to accumulate in the mortgage balance. If a mortgage instrument with an initial balance of $200,000.00 restricts negative amortization to ten percent of the initial balance, the remaining balance on the mortgage can never exceed $220,000.00. It should be noted that the imposition of caps on negative amortization or payments have no influence over the mandatory five year payment adjustment required by the AML regulations.

Another method of restricting changes in the parameters of a mortgage instrument is to limit the contract rate adjustment. This is done by placing a limit on the contract rate or by placing a limit on the increases in the contract rate at each adjustment period. Limiting the contract rate can be achieved in two ways. The first is to simply state that the contract rate cannot exceed a predetermined level. If an instrument has this type of cap, and its related index implies a contract rate in excess of the maximum, the implied rate is ignored and the contract rate is set equal to the maximum rate. Notice that for variable payment mortgages this approach eliminates the possibility of negative amortization provided no other caps are included in the instrument. The second lifetime contract rate cap is accomplished by limiting the internal rate of return that can be earned by the lender. This type of cap, when binding, forces the lender to alter the payment pattern in the final months of the mortgage. It is also possible that the lender will owe the borrower cash at the mortgage's termination to reduce the lender's internal rate of return to the amount allowed. This

type of cap does not influence the mortgage parameters until the mortgage approaches termination or is terminated.

The last form of parameter restriction is the periodic contract rate cap. This cap places a limit on the size of the change allowed in any adjustment period. If a mortgage restricts the change in the contract rate in any period to three percentage points up and four percentage points down, the contract rate is only able to increase by three points and decrease by four points regardless of the movement of the related index. This type of cap does not create negative amortization for variable payment mortgages when no other caps are present.

The potential complexity of Adjustable Rate Mortgages should be clear. Thousands of combinations of mortgage provisions are possible. To demonstrate the point a description of a few example instruments follows:

> A. Capped variable payment with payment shortages accounted for through term extension. If the term extension reaches 40 years, the shortage is attributed to the balance in the form of negative amortization until this amount reaches 5% of principal, then the payment is increased.
>
> B. Capped variable balance with increased payments to account for shortages.
>
> C. Capped yield to the lender with adjustments to the payments to reflect changes in the index rate.

D. Capped change in the interest rate, with adjustments made to the payment which is capped, and shortages reflected by increased term until its limit is reached followed by negative amortization with the catch-up every five years changing the payment.

The above examples represent a small number of the various combinations that can exist in the market. The potential number of mortgages under the AML regulations is only limited by the number of mortgages borrowers are willing to accept, and lenders are willing to write. Lenders will also look towards newly developing secondary markets for Adjustable Rate Mortgages to see which designs can be most easily sold or bought, affecting liquidity risk.

Chapter III

Literature Review

The majority of mortgage risk research has been conducted using ex-post data derived from fixed rate mortgage experience. Fixed rate mortgage risk studies generally use regression models to relate the condition of a mortgage, measured by various ratios, to the incidence of loss on the part of the lender. These studies have generated conclusions about the determinants of default, delinquency, termination and market risks that are consistent across time and sample.

The adjustable rate mortgage risk studies have used sensitivity analysis to measure the influence of adjustable mortgage loan contracts on the condition of a mortgage instrument. The instrument's condition is measured by the values of the ratios that have been widely supported as being determinants of various risk levels for fixed rate mortgages. The adjustable mortgage risk studies rely on simulated data to measure the performance of different instrument designs under assumed economic conditions. The adjustable mortgage risk studies have been consistent in their conclusions.

Mortgage Risks

Mortgage risk, from the lender's viewpoint, can be divided into two basic loss categories: actual and opportunity. Actual losses are the result of loan defaults and instrument sales at a market price that is below the remaining balance (assuming the mortgage was acquired at the remaining value). Opportunity losses are the result of delinquent

payments, increases in interest rates, and termination dates that deviate from the expected termination date. Delinquent payments cause opportunity losses whenever the late payment fee, if contained in the mortgage, is less than the reinvestment income that would have been received had the payment been made on time. Late payments can also disrupt asset/liability hedging strategies and result in the lender being forced to borrow at unattractive rates. The latter disruption can only be determined on a case by case basis with a complete disclosure of the specfic hedging strategy, asset and liability portfolio.

Deviations in the mortgage termination date occur for many reasons: divorce, relocation of the borrower, economic calls and economic puts.[10] Economic calls and puts are the result of changes in the mortgage market required coupon rate. When interest rates rise there may be incentive for the borrower to postpone relocating, creating an implied put. The loss to the mortgage lender is the opportunity cost of having his money invested in a below market return investment. Another form of mortgage put occurs when the mortgage is assumable, mortgage coupon rates have risen, and the house is sold with the existing mortgage. The new home owner continues to service the old, below market mortgage causing the opportunity loss for the lender to continue. The above situations create put losses only when the mortgage remains outstanding longer than expected. If the mortgage has not reached its expected termination date,

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[10] Hendershott, Patric H., Hu,S. and Villiani, Kevin E. "The Economics of Mortgage Terminations: Implications for Mortgage Lenders and Mortgage Terms." Housing Finance Review, 2, April 1983.

the opportunity loss is not a put loss, but is a market loss. Put losses can only occur after the mortgage has reached its expected termination date. Economic calls occur when the mortgage market required return rate falls relative to the mortgage coupon rate. The borrower may have incentive to call the mortgage, causing termination prior to the expected date. The loss to the mortgage lender is the difference between the old mortgage's above market coupon rate, and the current rate at which the funds can be invested. For the purpose of this paper only economic calls and puts will be considered. Other borrower-specific causes of mortgage termination must be viewed in the portfolio context or in the same way such factors are now considered for fixed rate mortgages, and such a discussion is beyond the scope of the present study. Each of these potential losses will be discussed in greater detail along with determinants of the events that lead to the losses.

Fixed Rate Mortgage Risk Studies

The following table presents a brief description of the major works on mortgage risk. This table is presented as an introduction to a description of each of the mortgage risk categories. The studies listed were used as a basis for the discussion of mortgage risks.

Summary Table of Literature

Date of Pub	Author	Method	Data Type	Description
9/62	Jung	Survey	Origination	Study compared mortgage costs based on differing loan to value ratios.
6/69	VonFurstenberg	Regression	Origination	Variables used are similiar to Herzog and Earley study. Significant result: Default has a time pattern.
1970	Herzog and Earley	Regression	Origination	Variables used included; loan/value, pay/income,term, loan purpose, subordinated debt, and borrower traits Results indicate that loan/value, payment/income, subordinated debt are positively related to default. Term was found to be negatively related to default.

Date of Pub	Author	Method	Data Type	Description
1/74	Bolten	Discriminant Analysis	Origination	Used variables that describe the loan at origination, regional employment data, and borrower traits. Results indicate that foreclosure and default are positively related to regional income.
10/78	Gau	Discriminant Analysis	Origination	Variables used include; loan/value, term, pay/income, secondary financing, and borrower traits. Results are the same as Herzog and Earley's.
2/83	Campbell and Dietrich	Regression	Life	Variables used included current loan/value, payment/income, difference between coupon rate and current mortgage contract rate. Results indicate that default and delinquency are related to current and original loan to value ratios, current payment to income ratios and unemployment.

Date of Pub	Author	Method	Data Type	Description
4/83	Hendershott Hu Villani	Simulation		Presented rational model for mortgage calls and puts based on present value of benefits and costs from calling or putting the mortgage.

DELINQUENCY RISK

Delinquency risk refers to the risk of borrowers' failing to meet their mortgage obligation in a timely manner. If a borrower fails to make his mortgage payment by the due date the lender suffers a loss. The loss is the denial of the use of funds to which the lender is entitled. This loss translates into foregone reinvestment income. These losses are measured by the present value of the earnings that would have materialized through reinvestment less the present value of any late fee paid by the borrower. The foregone earnings are determined by multiplying the current return on investment of the lender times the amount delinquent.

Literature on mortgage risks has focused primarily on default risk for obvious reasons (default creates the greatest potential loss). There are many studies that refer to delinquency risk, but treat it as a necessary precursor to default. There is a great deal of agreement about the determinants or indicators of default in both the theoretical and empirical writings. The studies can be divided into two categories by the type of data used: data collected on the mortgage origination date and data collected over the life of the mortgage. Campbell and Dietrich[11] conducted a study using life of the mortgage data. Their approach used the value of the residence, current loan balance, monthly payment, current monthly income of the household and other current

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[11] Cambell, Tim S. and Dietrich, J. Kimball. "The Determinants of Default on Insured Conventional Residential Mortgage Loans." Journal of Finance, 5 (December, 1983), pp. 1569-1581.

measures of the households financial condition to forecast loan difficulties. Previous studies used the same types of variables but only looked at their values when the loan was originated. Those using this methodology included Von Furstenberg[12,13,14], Jung[15], Rakes[16], Gau[17], and others. Among these studies the work by Herzog and Earley[18] is the most comprehensive. The lack of dissension among the studies provides an opportunity to limit further discussion mainly to the Herzog and Earley and Campbell and Dietrich studies with only occasional reference to other papers.

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12 Von Furstenberg, George M. "Default Risk on FHA-Insured Home Mortgages as a Function of the Terms of Financing: A Quantitative Analysis." Journal of Finance, Vol. 24 (June 1969), pp.459-477.

13 _____. "The Investment Quality of Home Mortgages." Journal of Risk and Insurance, Vol. 37, No. 3, (September, 1970), pp.437-445.

14 _____. "Risk Structures and the Distribution of Benefits within the FHA Home Mortgage Insurance Program." Journal of Money, Credit and Banking, Vol. 2 (August 1970), pp.303-322.

15 Jung, A. E. "Terms of Conventional Mortgage Loans on Exsisting Houses." Journal of Finance. September, 1962.

16 Rakes, G. K. "A Numerical Credit Evaluation Model for Residential Mortgages." Quarterly Review of Economics and Business.

17 Gau, George W. "A Taxonomic Model for the Risk-Rating of Residential Mortgages." Journal of Business, Vol. 51, No. 4, 1978, pp.687-706.

18 Herzog, John P. and Earley, James S., Home Mortgage Delinquency and Foreclosure, National Bureau of Economic Research Number 91, General Series. Columbia University Press, 1970, New York.

Herzog and Earley[19] investigated the factors that lead to mortgage delinquency and foreclosure. They developed a proposal and tested it using a cross-section of mortgage data collected in 1962 from the United States Savings and Loan League, Mortgage Bankers Association, and the National Association of Mutual Savings Banks. Multiple regression models were used to test the significance of ten variables on the incidence of delinquency. These variables were:

1. Loan purpose or presence of junior financing
2. Loan to value ratios
3. Initial term to maturity
4. Occupation
5. Number of dependents
6. Payment to income ratios
7. Mairtal status
8. Borrower Age
9. Region
10. Loan type (conventional or FHA/VA)

Variables 1,2,3,6 and 10 describe the condition of the mortgage using terms that are related to the mortgage and the mortgage issuing pro cess. Variables 4,5,7,8 and 9 describe the borrower and do not relate directly to the mortgage. The multiple regression employed a dummy variable as the dependent with a value of 1 for loans that are delinquent and a value of 0 for current loans. The results indicate the following relationships:

1. The purpose of the loan was a strong indicator of delinquency. If the loan's purpose was refinancing an old mortgage or junior financing existed, the probability of the loan being delinquent increased.

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[19] Ibid.

2. The loan to value ratio also was positively and significantly related to a loan becoming delinquent.

3. The payment to income ratio was not significantly related to delinquency. This puzzling finding can be explained by looking at the characteristics of the mortgages in the the sample. "Study showed that most loans in the samples had payment to income ratios below twenty-five percent".20 This indicates that that lenders pay close attention to the the payment to income ratio at the time a loan is originated. This creates a prescreened data set that may account for the lack of an insignificant relationship between the payment/income ratio and delinquency. Another factor that may have contributed to this finding is that the values used in this study were all from the time of loan origination and not from the point at which the loan became delinquent.

4. The initial term to maturity was not significant.

5. Government insured loans, FHA and VA, have a higher probability of being delinquent than non FHA, VA loans did. FHA and VA loans generally have more liberal financial terms than conventional mortgages. This is especially true of the loan to value ratio. When the effect of the differences in this term are accounted for, the FHA and VA loans actually carried lower delinquency risk than conventional mortgages.21

The mortgage traits that effect delinquency according to Herzog and Earley[22] are junior financing and the loan to value ratio. The Herzog and Earley study shows that there is no significant relationship between

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20 Ibid. pp.xvii.

21 Ibid.

22 Ibid.

the initial payment to income ratio and the delinquency rate. It has already been pointed out that this result may be due to the prescreening of the mortgage data: therefore, the payment to income ratio will not be eliminated from future discussion of delinquency risk.

A recent study by Cambell and Dietrich[23] using data from Mortgage Guarantee Corporation of America and Regional Data Associates hypothesizes that delinquency is affected in the same way as default. They hypothesize that default is influenced by the current loan to value ratio (previous studies used initial), the current payment to income ratio (previous studies used initial payment to income ratio), regional unemployment, and changes in the required rate of return on mortgages. Their study is the first to use current loan data as opposed to initial loan data. The significant results of their regression for delinquency indicate that the current loan to value ratio is negatively related, current payment to income is positively related, unemployment is positively related, and the change in mortgage required return rates is negatively related. All of these findings except for the loan to value relationship are as expected and easily explained.

The most interesting finding of Cambell and Dietrich is that the loan to value ratio is negatively related to delinquency. This is interesting because it is the opposite of what is expected. The authors leave this result unexplained calling it "difficult to rationalize".[24]

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[23] Cambell, Tim S. and Dietrich, J. Kimball. "The Determinants of Default on Insured Conventional Residential Mortgage Loans." Journal of Finance, 5 (December, 1983), pp. 1569-1581.

[24] Ibid. pp.1574.

A possible explanation is that in the mortgage initiating process borrowers with the greatest capacity to pay, highest credit rating and character to pay, are given higher initial loan to value ratios. Borrowers that are considered riskier, i.e. more likely to become delinquent, are saddled with lower loan to value ratios. This explanation seems logical for delinquency which has been defined as late payment without subsequent foreclosure. The delinquency decision does not involve loss of title where the default decision does. This implies an individual may find economic reasons, as described above, to become delinquent; but, under the same conditions, he may not find economic reasons to default. Therefore, the delinquency decision is not related to the default decision and should be treated as a different circumstance.

The relationship between the mortgage coupon rate and the current mortgage market coupon rates (assuming no buydowns) has a negative impact on delinquency. The variable used to describe the change in interest rates was (Rt-Ro)/Rt. Where Rt is the current mortgage market coupon rate (no buydowns) and Ro is the coupon rate on the old fixed rate mortgage. If this ratio is positive then it can be assumed that the yield curve has shifted upward causing all interest rates to be higher in the current period than they were when the mortgage was initiated. To avoid delinquency a borrower can seek a short term loan allowing him/her to make the payment on time. This strategy seems logical as long as the interest payment on the short term loan is lower than the late fee associated with the mortgage. This condition should not occur if interest rates have risen. Therefore, when interest rates rise borrowers

who face rationing may find deferring the mortgage payment to be a relatively cheap source of borrowing. This will encourage delinquency.

It is also possible for a borrower who does not face rationed consumption to become delinquent intentionally. If interest rates rise to the extent that the interest earned on short term investments exceeds the the late fee, then a rational borrower would delay his mortgage payment, invest it at current market rates, and, at a later date, when the consequences of not servicing the mortgage become more severe and foreclosure is threatened, make the payment along with the late fee. His profit would be the difference between the interest earned and the late fee. In most cases this would not take place because the gains will be trivial due to the size of mortgage payments and the fact that lenders can force foreclosure in a relatively short period of time. This implies that the relationship between the mortgage coupon rate and current market interest rates will affect the level of delinquency only to a minor degree.

The primary determinant of delinquency appears to be the current payment/income ratio. The initial payment/income ratio failed to be consistent in both the theory and empirical relationships for the reasons cited above. The current loan to value ratio was shown to be negatively related. The initial loan to value ratio was shown to be positively related. The apparent conflict raises issues about underwriting bias and the change in the use of government and private mortgage insurance over the period between the two studies. The conclusions that could be drawn from using the loan/value ratio to

predict delinquency would be subject to wide interpretations based on underwriting bias and mortgage insurance effects. The change in the level of interest rates as measured by Campbell and Dietrich will also have an effect on delinquency. "The decision to delay payments remains more difficult to explain in a satisfactory manner" than default.[25]

Default Risk

Default occurs when a debtor decides to discontinue or is unable to continue meeting the monthly payment obligation of the mortgage instrument for an extended period. This forces the lender to foreclose on the property. Default losses are incurred by the lender to the extent of the difference between the mortgage balance and the amount recoverable from the sale of the property and assets of the lender net of sales and collection costs. The key determinant of the size of the loss will be the relationship between the market value of the residence and the loan balance. Secondary recoveries from the assets of the debtor are generally small after collection costs. The decision to default, when rational, considers the total benefits and total costs of defaulting. If the debtor, after comparing the costs and benefits, decides to default, it is probable that the lender will suffer a loss. The causes of default have been discussed by a number of authors and the conclusions are consistent. A few of the studies will be reviewed to

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[25] Cambell, Tim S. and Dietrich, J. Kimball. "The Determinants of Default on Insured Conventional Residential Mortgage Loans." Journal of Finance, 5 (December, 1983), pp. 1569-1581.

provide insight into the determinants of default.

The Herzog and Earley study tracks the changing mortgage terms over the post war period and develops conclusions about the changes in the risk traits of mortgages. Their findings concerning delinquency risk have already been discussed. They divided default risk into two categories, conditional and direct. Conditional default tested the relationship between loans that are delinquent and the set of these loans that proceeded into default. Direct default looked at the entire universe of mortgages and the subset that entered default. In both cases, the authors tested the relationship of the same variables that they used to explore delinquency risk.

The relationship between the tested variables - loan purpose, loan/value ratios, initial term to maturity, occupation, dependents, payment/income ratios, marital status, borrower age, region and loan type - and conditional default is identical to the relationship between the variables and delinquency risk in all but three cases. The term to maturity is negatively related to delinquency, but, bears a direct relationship to conditional default. This finding can be justified because the longer initial term loans will have a slower equity build-up. This reduces the potential benefits of continuing to service the mortgage (gains recognized upon sale). Occupation proved to be a non-significant indicator of conditional default.

Loan purpose demonstrated its significance in the default process in the same way it did as a determinant of delinquency. Loans whose purpose is the construction of a new home or refinancing an old mortgage contained a relatively high amount of conditional default risk. Each of

these relationships can be rationalized. When the loan purpose is the construction of a new home, the borrower may be more willing to enter default because it does not involve moving and the other costs of displacement. Also, the new home may not be completed, or, when finished may not be what the borrower envisioned. In these cases the borrower may not be as reluctant to default. In the case of refinancing the primary question to be asked is why was the loan refinanced.

At the time of this study the range in mortgage interest rates was relatively small. This would tend to imply that most refinancing was done to extend the mortgage term and decrease the monthly payment. In other words the refinancing was done to avoid delinquency or default on the original mortgage. When the new mortgage becomes delinquent and faces default there could be relatively little advantage to refinancing over a longer term (that is, the monthly payment cannot be further reduced by lengthening the term). Another reason for default could be the relationship between the new loan's balance and the market value of the house. The new mortgage may have consumed the equity that was built up in the old mortgage. In general, the causes of conditional default are the same as the causes of delinquency.

Straight default risk is indicated by the same variables as conditional default risk. The key indicators of default are: loan purpose, junior financing, term to maturity, and loan to value ratios. Loans whose purpose is the construction of a new home or home repair or addition have an increased level of default risk. The same rationale that was applied for conditional default applies here. Mortgages with

the presence of junior financing also possess increased default risk. Second mortgages decrease the amount of equity held by the borrower, thus decreasing his incentive to continue to meet the monthly mortgage obligation. Longer terms to maturity create higher levels of default risk because they reduce the relative speed of equity accumulation in the home. Higher loan to value ratios indicate lower equity which explains why they have a positive relationship with default. In general, the level of default risk can be described by the potential loss to the home owner upon default. That is, each of the default predictors influenced the total cost of default. The lower this cost the greater the probability of default.

The final step of the Herzog and Earley[26] study was to fit the cross-sectional data into time series equations to determine if the quality of mortgages had changed over the postwar period. Several of the variables that were found to predict default were calculated for mortgages for each year from 1957 to 1963. These variables included: loan to value ratios, term to maturity, payment to income ratios, loan purpose, and junior financing. The results of the time-series equations indicate that the home mortgage performance over the period can be explained by the changes in the variables used in the time series. The increasing level of default over the post war period can be explained by the continued liberalization of the mortgage terms that indicate default.

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[26] Herzog, John P. and Earley, James S., Home Mortgage Delinquency and Foreclosure, National Bureau of Economic Research Number 91, General Series. Columbia University Press, 1970, New York. pp.xvii.

The Herzog and Earley study demonstrated that the financial terms of a mortgage have an impact on the risk level of the loan. All of the financial terms that affect default can be described as "equity influencers", terms that have a direct or indirect affect on the market equity contained within the home.

Cambell and Dietrich[27] have investigated the relationship between various variables and default also. Their study has several significant differences from the Herzog and Earley study, although the conclusions are very similiar. The most important distinction is that Cambell and Dietrich use current mortgage data as opposed to variable values at origination to determine the variables that influence default. A second difference is in approach. Cambell and Dietrich model default as a consumer choice. They also introduce a new variable that is a function of market interest rates. Other than these items the findings are generally consistent with the earlier studies.

The model chosen by Cambell and Dietrich states that a borrower must select from four alternative courses of action: delinquency, default, prepayment and normal service. The decision will be a function of the state of the world on the day the decision is made. This implies that the current mortgage traits traits. They hypothesize that the default decision will be a function of the loan to value ratio at time t, the payment to income ratio at time t, the relative spread between

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[27] Cambell, Tim S. and Dietrich, J. Kimball. "The Determinants of Default on Insured Conventional Residential Mortgage Loans." Journal of Finance, 5 (December, 1983), pp. 1569-1581.

the current must be used to predict the decision and not the initial mortgage and original mortgage rate, regional unemployment rate, type of house and age of the mortgage.

Over the life of a mortgage the borrower may face adverse circumstances that lead to obligations that are greater than income. When this occurs the borrower must determine what payments to make and those that are to be ignored. Borrowers in this condition should avoid defaulting on their home loan until "equity values have deteriorated to the point that default is the borrower's least-cost action".[28] The costs involved in default are the direct loss on the property plus any increase in future borrowing costs due to the default, according to Cambell and Dietrich. An additional cost which they elect to ignore is the cost of moving (finding a new home and moving there). This cost may have significant impact on the default decision. This decision has two distinct steps. The first involves the decision to fail to service the mortgage causing delinquency. The impact of this decision is minor. Cambell and Dietrich propose that the probability of this occurring is a function of the current payment to income ratio. The second step involves a comparison between the costs of default and the ability to meet all obligations. At this point the decision should be a function of the amount of equity that the borrower has built up in the home. This is measured by the current loan to value ratio. "Hence, the probability of default should be positively related to both the payment/income ratio

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[28] Ibid., p. 4.

and the loan/value ratio".[29]

The incidence of default should also be negatively related to the relative spread between the current and original mortgage rate, (Rt-Ro)/Rt. As the spread increases (current rates exceed original rate) the value of the mortgage increases to the borrower. If the loan is assumable, the value of the house to a potential buyer is enhanced by bundling the house with the below market coupon rate mortgage. This would imply that the borrower could sell his home prior to defaulting and avoid the other costs associated with default.

The initial loan to value ratio was included in the empirical test because it has been shown to be a significant predictor of default in several other studies, including those by Von Furstenberg,[30] Gau,[31] and Bolten.[32] There are two possible reasons for the initial loan to value ratio to be positively related to default. The first is that the initial ratio serves as a proxy for future ratios. It is far more likely that a loan with a high initial loan to value ratio will have a high loan to value ratio in the future. The second reason is that the loan to value ratio serves as a proxy for the wealth level of the borrower. Those

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[29] Ibid., p. 4.

[30] Von Furstenberg, George M. "Default Risk on FHA-Insured Home Mortgages as a Function of the Terms of Financing: A Quantitative Analysis." Journal of Finance, Vol. 24 (June 1969), pp.459-477.

[31] Gau, George W. "A Taxonomic Model for the Risk-Rating of Residential Mortgages." Journal of Business, Vol. 51, No. 4, 1978, pp.687-706.

[32] Bolten, Steven E. "residential Mortgage Risk Characteristics." Decision Sciences, 5 (January 1974), p. 73-85.

with increased wealth have the capacity to make larger down payments causing a lower loan to value ratio. A relatively high wealth level when the mortgage is issued is more likely to indicate relatively high wealth levels through the life of the mortgage. It has also been hypothesized that the low initial loan to value ratios are associated with loans that are more likely to default. This proposal presumes that loan officers force those in high risk categories to make larger initial down payments to insure that the lending institution avoids a loss upon default. By including both the current and initial loan to value ratio the effect of the former can be determined.

The regional unemployment rate is held to be positively related to the default rate. This seems logical because as unemployment goes up the probability of income remaining constant goes down creating new payment to income ratios. The value of property in an area with high relative unemployment generally declines. This creates higher loan to value ratios. The combined effects should cause unemployment to be positively related to default.

The type of house purchased serves as a surrogate for the type of purchaser. It is assumed that younger individuals who are more transient and have a higher probability of facing adverse personal and financial problems are more likely to purchase a new home. Therefore, a mortgage on a new home should have a higher probability of default than a mortgage on an old home.

The final determinant of default is the age of the mortgage.

Von Furstenberg[33] and others have demonstrated that the probability of default begins low and increases until the mortgage is 3 to 4 years old. At this point the probability of default peaks and begins to decline until the 12th year. From the 12th year on, the incidence of default is not significant. This pattern is clearly not linear, so, Cambell and Dietrich[34] included the age of the mortgage and the age squared. The rationale for the default pattern related to time is, that, in the first few years the utility of home ownership is very high causing the borrower to sacrifice to meet his mortgage payment. As time passes the utility of owning a home diminishes, causing the willingness of the borrower to sacrifice to meet the mortgage payment to decline.

In the first few years there is very little equity build-up in the home. Between 3 and 4 years the equity build-up begins to accumulate. At this point the equity sacrificed by defaulting exceeds the benefits gained, so the probability of default declines. Essentially there are two forces at work and both move in opposite directions. The first is the utility of home ownership. It begins high and declines. The second is the economic value of the home. This starts very small and builds. When the mortgage is 3 to 4 years old, the utility of owning a home has declined enough to allow default and the economic value of home

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[33] Von Furstenberg, George M. "Default Risk on FHA-Insured Home Mortgages as a Function of the Terms of Financing: A Quantitative Analysis." Journal of Finance, Vol. 24 (June 1969), pp.459-477.

[34] Cambell, Tim S. and Dietrich, J. Kimball. "The Determinants of Default on Insured Conventional Residential Mortgage Loans." Journal of Finance, 5 (December, 1983), pp. 1569-1581.

ownership has not grown enough to prevent default. After this point the equity build-up prevents default, and, before this point the utility of homeownwership prevents default.

The empirical results of Cambell and Dietrich support the proposed relationships. Of particular importance is the fact that the initial and current loan to value ratios are significant determinants of default. This implies that there may be some serious risk problems with mortgages whose terms could cause variation in the loan balance, payment or term.

The results of the studies on default risk indicate that the level of equity in a home is a primary determinant of default. Most of the relevant variables have a direct impact on the rate of equity accumulation or initial equity levels. The other variables tend to address the preliminary question of whether or not the monthly payment is to be made. This issue can be viewed as a predecessor to default even though delinquency does not imply that default will occur. However, default does not occur without delinquency.

Interest Rate Risk

Interest rate risk is the potential loss associated with deviations in the price of a fixed income security due to changes in market interest rates. Changes in the market value of a fixed rate security will be a function of that security's duration and the size of the change in market interest rates. For any given change in interest rates, instruments with longer durations will have greater changes in market value. For any given duration the size of the price change will increase as the size of the change in interest rates increases. This risk is significant to lenders of mortgages. Mortgages typically have long

durations, which means the value of a portfolio of mortgages is subject to relatively large changes as interest rates fluctuate. In the typical fixed rate mortgage the borrower holds all the cards in relation to interest rate risk. If interest rates fall the borrower can relieve himself of the higher interest rate obligation by exercising his call privilege. The mortgage lender does not have such an option when interest rates rise with fixed rate mortgages. The mortgage lender accepts a disproportionate amount of interest rate risk. For this reason the remainder of this discussion will focus on the risk of the mortgage holder. The borrower's risk will be discussed in the next section dealing with mortgage termination.

A short example will disclose the significant impact interest rate risk has on mortgage holders. Assume a $60,000 mortgage was issued in 1978 with 2% closing costs, 8% coupon rate, a prepayment penalty of 3%, a term of 20 years and an expected life of 20 years. Two years later the same mortgage would carry a 15% coupon rate. Because the two instruments carry the same risk and approximately the same maturity date, they would trade at roughly the same expected return or yield to maturity in the market place. This means the 8% coupon rate mortgage with a remaining balance of $57,358.20 would have a value of $36,434.50. The loss to the mortgage lender is $20,923.69 or 36%. Such losses cannot be sustained by any firm or individual over an extended period with any probability of survival in the business of lending. It is worth repeating that the mortgage lender does not have an option to renegotiate the mortgage coupon rate. If he did, the coupon rate could be increased to the

current market rate and the value of the mortgage would be the remaining balance. Interest rate risk associated with long duration fixed rate mortgages is borne almost entirely by the mortgage lender, and this can cause significant and unacceptable losses to him/her. Perhaps the greatest weakness of the standard fixed rate mortgage is that interest rate risk is not symmetrical. Lenders assume all downside risk and have limited upside potential due to the borrower's call privilege.

Mortgage Terminations

There are two classes of mortgage termination: premature and mature. Premature termination can occur at any point up to the original maturity date for the mortgage. Mature termination can only occur at the maturity date called for in the mortgage contract. Either of these conditions can have adverse effects on lenders. The key issue in the effect of terminations on lenders is the relationship between the mortgage coupon rate and current mortgage market coupon rate. If current rates are higher than the coupon rate, the mortgage's value will be lower than the remaining balance, leaving the lender with a capital loss and the borrower with a gain in the form of monthly mortgage payments that are lower than the market requires on current mortgages. The opposite relationship holds if the coupon rate is higher than the current mortgage rate. The lender and borrower have opposite positions that are not equal. The lender does not have the ability to put the mortgage while the borrower has the ability to call or default on the mortgage. In other words the termination options are controlled by the borrower and not the lender. Each option will be discussed separately.

The analysis assumes fixed rate, fixed maturity instruments.

Calling the Mortgage

There are three potential conditions that will cause a borrower to call his mortgage: cash constraint; better financing becomes available; or the house is sold. The cash constraint can generally be viewed as an irrational reason to refinance a home, because there are other alternatives that will provide cash and have a lower economic cost. Better financing becomes available when the current mortgage market coupon rate is lower than the old mortgage's coupon rate. When a house is sold there are two potential options for the buyer: purchase the old mortgage with the house (only when loan assumption is allowed under the old mortgage), or, purchase the house alone. The buyer's decision forces the borrower to either prepay the loan with the proceeds from buying the house, or, pass the loan on to the buyer. The buyer will decide to assume the loan if it provides below market rate financing, and, the borrower does not demand too high a premium for providing the financing. The dominant consideration in determining whether or not to call a loan is based on the economic value of the mortgage.

The concept of a cash constraint was introduced by Peterson.[35] Under conditions of inflation the market value of a home should increase as the remaining balance of the mortgage declines. The combined effect of these two events is a rapid increase in the equity value contained in

[35] Peterson, Peter T. "The Effect of Inflation on the Probability of Mortgage Prepayment." Working Paper. College of Business Administration, Arizonia State University, December 1979.

the house. Some individuals' utilities may be increased by changing their consumption pattern and consuming part of the equity value in their homes in the current period. In order to accomplish this, the homeowner can issue a second mortgage, refinance the primary mortgage, or, sell the house. Assuming the latter option is not acceptable because of the need for a place to live, the homeowner must choose between refinancing and a second mortgage. If the choice is made on economic grounds, the borrower will choose the method that minimizes the present value of the cost of the funds.

An example will serve to demonstrate the decision process. The house involved has a current market value of $60,000. The old mortgage had a beginning balance of $27,990, was 8 years old, and, had an original maturity of 30 years. The opportunity cost of funds is 10%.

	Old Mortgage	Refinance	Second
Coupon Rate	10	13.5	15
Pre-Pay %	3	3	3
Closing %	2	2	2
Monthly Pay	$245.75	$618.30	$448.73
Balance	$26180.30	$54000.00	$27819.70
Term (years)	22	30	10

The present value of refinancing is $72,320.70.
The present value of using a second mortgage is $60,704.30.

To consume the equity build-up in a house a borrower has two viable options: second mortgage and refinancing. In the above example the borrower has conflicting information. If he wishes to minimize his payments over the short run, he should to refinance the mortgage creating a monthly payment of $618.30. This is considerably less than the payments associated with the combination of a first and second mortgage, $694.48. If the borrower wishes to minimize the cost of

consuming the equity build-up, he should compare the present value of the two options. The use of a second mortgage has a present value of $60,704.30 which is much less than the present value of refinancing, $72,320.70. The decision for the borrower is based on his current cashflow. The borrower may be in an adverse position that forces him to minimize current cashflow requirements at the expense of minimizing cost. In other words the borrower may opt for the more expensive option in order to reduce his short term cash requirements. The cash constraints motive only applies when a borrower projects a short term cash shortage.

The primary motivator behind calling or putting (selling the mortgage to the new homeowner along with the house) the mortgage is the relationship between current home mortgage interest rates, the coupon rate on the old mortgage, the prepayment penalty, and, the current rate of closing costs. If the house is not being sold the borrower has the option of calling the mortgage and refinancing the balance or continuing with the old mortgage. This decision will depend on the difference between the old mortgage's coupon rate, the current coupon rate, the prepayment penalty, and the closing cost on the new mortgage.

An example will clarify the decision process. Assume a house with a market value of $60,000 has a mortgage with an initial balance of $54,000 that is one year old. The coupon rate on this mortgage is 17% and the prepayment penalty is 3%. The original life of the mortgage was 30 years. Current interest rates have fallen to 12% with 2% closing costs and 30 year life. Should the homeowner refinance his old mortgage

to take advantage of the decline in interest rates? The answer can be found by comparing the present value of the relevant costs of each option after taxes. Assume the homeowner can have his funds invested in a savings account that pays 10% annually. The present value of the current mortgage is $87,258.90. The present value of refinancing including prepayment penalties and closing costs is $65,940.70. It is apparent that the homeowner should refinance. Another way of looking at this problem is to determine the benefits and costs associated with refinancing. If the benefits exceed the costs the loan should be refinanced. The primary benefit of refinancing will be the reduced monthly payment. The costs will be the call premium and the new loan closing costs. Henderschott, Hu and Villani[36] followed this approach and found the benefits to be:

$$Brk = \frac{\dfrac{[PAY(io,X,M) - PAY(io,PRIN(io,X,M,k),M-k]}{(1+i_m)^{t} - k}}{\dfrac{[PRIN(im,X,M,k) - PRIN(im,X,M,k)]}{(1+i_m)^{L} - k}}$$

where; i is the coupon of the original mortgage, X is the initial principal amount, M is the term, k is the period in which the

[36] Hendershott, Patric H., Hu, S. and Villiani, Kevin E. "The Economics of Mortgage Terminations: Implications for Mortgage Lenders and Mortgage Terms." Housing Finance Review, 2, April, 1983.

termination decision is being made, and i is the current mortgage market coupon rate.The first term is the present value of the difference between the two mortgage payments and the second term represents the difference in amortization rates between the two mortgages. The costs associated with refinancing are:

$$CR=(C+P+V)*PRIN(i_o,X,M,k)+T$$

where: C is the closing cost expressed as a percent of principal on the new loan, P is the prepayment penalty or call premium of the old loan, T is the value of the effort and time required to refinance the mortgage, and V is any points that may be charged on the new loan. V is generally associated with a loan that has a "below market" coupon rate. The greater the decline in interest rates the greater the benefit associated with refinancing. The greater the closing costs and prepayment penalties the greater the costs of refinancing. If the benefits exceed the costs the homeowner should refinance.

The refinancing or call decision rises out of a decrease in interest rates. The key determinants of the decision are: the magnitude of the fall in interest rates, the prepayment penalty, the closing cost on the new mortgage, the remaining life of the old mortgage, and the expected time until termination of the new loan. The larger the decline in interest rates the greater the benefit from refinancing. Larger prepayment penalties and closing costs decrease the net benefit from refinancing. The smaller the marginal tax rate of the borrower, the longer the remaining life of the old mortgage and the longer the expected life of the new mortgage, the greater the potential benefit

from refinancing. The interaction of these terms determines the net benefit from refinancing.

Mortgage Puts

If interest rates rise the homeowner has the ability to put or assume the old mortgage. There are two types of puts, explicit and implicit. The explicit put occurs when the home is sold and the new owner assumes the old mortgage. When this occurs the old mortgage remains on the books of the mortgage lender at its market value. The implicit put occurs when the homeowner remains in his present house for a period of time longer than he would if interest rates had remained constant. The higher interest rates create a larger monthly payment on a new mortgage that would be associated with a new dwelling. To avoid the higher payment the homeowner does not change dwellings. This extends mortgage life in basically the same way an explicit put or assumption does. The key determinants of the mortgage put are the size of the increase in mortgage interest rates, the prepayment penalty (this cost is often forgiven by mortgage lenders on below market coupon rate mortgages), new loan closing costs, and the condition of the housing market.

Summary of Fixed Rate Traits

Literature has explored the traits of fixed rate mortgages using risk terminology. In particular delinquency, default, interest rate and termination risks have been discussed along with some of the determinants of these risks. Factors that will be used to investigate the risk associated with the new adjustable rate mortgages include current and initial payment to income ratios, current and initial loan to value ratios, "TILT", variance in interest rates, time period between interest rate changes, potential negative amortization (secondary financing), and term to maturity. The rest of this dissertation will focus on how these variables may affect the risk of adjustable rate mortgages.

Adjustable Rate Mortgage Risk

The literature on Adjustable Rate Mortgages has concentrated on default, delinquency, shock and instrument standardization. The impact of ARMs on default and delinquency risk have been examined by Webb,[37]

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[37] Webb, Bruce G. "Borrower Risk under Alternative Mortgage Instruments." Journal of Finance. Vol. 1 (March 1982), p.169-183.

Vandell,[38] Swan,[39] and others. Guttentag[40] discussed the difference between trend and shock and how the difference may affect the condition of a mortgage. He, along with, Lea and Brown,[41] and Colton, Dougherty and Villiani[42] examined the impact that the lack of instrument standardization may have upon mortgage markets. The methodologies and conclusions of these studies are presented according to risk category. The standardization issue is presented last.

ARM DELINQUENCY RISK

It is generally agreed that delinquency risk is a function of a mortgage's payment to income ratio. As the payment to income ratio rises the probability of a loan becoming delinquent rises. There are two events that can cause the payment to income ratio to increase. The first is an increase in the monthly payment that is proportionately larger than increases in the monthly income of the borrower. This cannot occurr with a fixed rate mortgage because there is no mechanism to allow the

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38 Vandell, Kerry D. "Default Risk under Alternative Mortgage Instruments." Journal of Finance. Vol. 5 (December 1978), p. 1279-1295.

39 Swan, C. "AMI Default and Foreclosure Analysis." Alternative Mortgage Instrument Research Study, Vol. II. Federal Home Loan Bank Board, 1977.

40 Guttentag, Jack M. "Solving the Mortgage Menu Problem." Presented at ARUEA Mid-Year Meeting, Washington D.C. 1983.

41 Lea, Michael J. and Brown Carolyn. "ARM Pricing: Theory and Practice." Presented at AREUEA Mid-Year Meeting, Washington D.C., 1984.

42 Colton, Kent W. Dougherty, Ann J. and Villiani, Kevin E. "Optimal Design Charicteristics of Alternative Mortgage Instruments." Working Paper. May 26, 1983.

monthly payment to change. Monthly payments may change under adjustable rate mortgage instruments. The second is a decrease in the monthly income of the borrower that is proportionately larger than decreases in the monthly payment. This can occur under any type of mortgage contract. The question that has been addressed by the literature into delinquency risk is whether or not the potential increase in the payment to income ratio caused by a disproportionate increase in the monthly payment significantly increases the risk of a mortgage falling into delinquency.

This issue has been directly addressed by Webb.[43] He viewed the mortgage payment as a burden on the borrower and the payment to income ratio as a gauge of the size of that burden. Webb defined Potential Delinquency as the burden imposed on a household to meet the monthly mortgage payment. This burden is a function of the mortgage payment, income and other expenses. The potential delinquency of a mortgage increases any time the borrower must choose between consumption of goods and consuming (paying for) housing. This implies that the potential delinquency of a mortgage is influenced by the change in payments as much as it is by increases in non-housing expenditures. Webb has proposed four empirically testable states of potential delinquency, each determined by the relationship between the initial payment to income ratio and the current payment to income ratio. The four conditions are:

$$PD1 = M_t / Y_t > M_o / Y_o$$

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[43] Webb, Bruce G. "Borrower Risk under Alternative Mortgage Instruments." Journal of Finance. Vol. 1 (March 1982), p.169-183.

$$PD2 = PD1 + M_{t+1}/Y_{t+1} > M_o/Y_o$$

$$PD3 = \sum_{t=1}^{n} (M_t)/(Y_t) > M_o/Y_o$$

$$PD4 = M_t/Y_t > 1.1*(M_o/Y_o)$$

where M_t is the monthly payment in month t, Y_t is the monthly income in month t, M_o is the initial monthly payment and Y_o is the initial monthly income. Each of the potential delinquencies is directly related to the monthly payment. PD4 eliminates trival increases in the payment/income ratio from being classified as potentially delinquent. Webb simulated the performance of six mortgage instruments using income and interest rate data from 1968 to 1975. The instruments included: fixed rate, 3% dual rate, 3% graduated payment, price level adjusted, adjustable rate tied to 3 month T-bill with 1/2% maximum annual rate increase, and adjustable rate tied to 3 year treasury note with 1/2% maximum annual rate increase. All of the instruments except the fixed rate have monthly payments that are subject to increases implying increased delinquency if income levels do not increase proportionately. The relationship between the change in payments, which is a function of the change in the related index, and the change in income will determine delinquency risk exposure.

In general high interest rates create a contraction in the economy, implying increased unemployment and therefore decreased aggregate income. When interest rates rise, causing an increase in monthly payments, there is no reason to believe real income will rise in the short run. In fact, it is more likely that real income will fall in the

short run, increasing the mortgage payment burden and the probability of delinquency.

Webb's results indicated that instruments with variable payments possess a relatively larger exposure to delinquency risk. Further, mortgage instruments that allow relatively large changes in the monthly payment over a short period, payment shock, will increase the probability of delinquency more than instruments that provide a gradual change in payments over time, payment trend. Guttentag[44] has supported this conclusion and recommended the inclusion of payment adjustment caps in instruments with adjustable payments. In general Webb found that mortgage instruments that allow changes in the monthly payment contain a greater level of delinquency risk than instruments with a constant monthly payment.

ARM Default Risk

Swan[45] and Vandell[46] have explored the impact alternative mortgage instruments have upon default risk. These studies conclude that equity accumulation is the key to measuring the level of default risk associated with any ARM design. If an ARM design slows or inhibits the accumulation of equity it will generate increased default. Designs that

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44 Guttentag, Jack M. "Solving the Mortgage Menu Problem." Presented at ARUEA Mid-Year Meeting, Washington D.C. 1983.

45 Swan, C. "AMI Default and Foreclosure Analysis." Alternative Mortgage Instrument Research Study, Vol. II. Federal Home Loan Bank Board, 1977.

46 Vandell, Kerry D. "Default Risk under Alternative Mortgage Instruments." Journal of Finance. Vol. 5 (December 1978), p. 1279-1295.

contribute to the rapid accumulation of equity will generate decreased default. The methodology of the two studies is significantly different. Swan argues that Vandell's methodology is invalid because Vandell uses a model that was developed from fixed rate mortgage experience.

Vandell states that default is driven by two separate causes, borrower characteristics and mortgage instrument attributes. Relying on earlier fixed rate mortgage studies by Von Furstenberg[47] and others, Vandell states that default is a function of borrower income, payment burden ($Payment_t / Income_t$), equity accumulation ($Loan\ Balance_t / Value\ of\ House_t$), and a transient time factor. Two of these factors can be directly influenced by mortgage instrument design: payment burden and equity accumulation.

Mortgage designs that allow monthly payment changes to reflect changes in interest rates have the potential to cause increase in the payment to income ratio. This occurs when the increase in monthly payments is greater (measured in percentage change) than increases in monthly income. Designs allowing negative amortization or changes in the monthly principal repayment may cause the loan to value ratio to increase at a slower pace or decrease. Mortgage designs that allow changes in the contract amortization rate to be reflected by changes in the monthly payment or in the pattern of principal repayment may increase the probability of default.

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[47] Von Furstenberg, George M. "Default Risk on FHA-Insured Home Mortgages as a Function of the Terms of Financing: A Quantitative Analysis." Journal of Finance, Vol. 24 (June, 1969), p.459-477.

Von Furstenberg's transient time factor is a result of the pattern of fixed rate mortgage defaults he discovered. This pattern suggests that the probability of mortgage default is very low the first year of the mortgage and increases rapidly until the fourth year. From the fourth to the tenth year the probability of default declines unitl it is insignificant. It remains insignificant for the remainder of the mortgage life. This pattern can be rationalized by examining the utility and economic costs associated with default. The utility of home ownership is very high immediately following the purchase of a home and declines with the passage of time. While utility is declining, equity is increasing at a very slow rate. By the fourth year of a mortgage, the utility cost of defaulting has decreased enough to make default a viable option. The economic costs of defaulting (loss of equity accumulation) on a fixed rate mortgage have not increased enough to make default financially unacceptable. Therefore, two reasons to avoid default lack substantial costs. As the fixed rate mortgage continues to age, equity accumulates creating a barrier to default. By the tenth year of the mortgage there is a substantial accumulation of equity, eliminating default from the list of options available to a borrower.

Vandell[48] used the Von Furstenberg[49] study to build a model

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[48] Vandell, Kerry D. "Default Risk under Alternative Mortgage Instruments." Journal of Finance, Vol. 5 (December 1978), p. 1279-1295.

[49] Von Furstenberg, George M. "Default Risk on FHA-Insured Home Mortgages as a Function of the Terms of Financing: A Quantitative Analysis." Journal of Finance, Vol. 24 (June, 1969), p.459-477.

of mortgage default. He then simulated the performance of several different mortgage instruments under eight assumed sets of conditions. The eight conditions generated different patterns for the value of the house, borrower income, interest rates, and different down payments and mortgage termination points. The results indicated that the adjustable rate mortgage had lower default risk when the movement in interest rates was restricted to one hundred basis points above and below the initial contract rate. For all instruments tested: fixed rate, adjustable rate, graduated payment and price level adjusted, the primary determinant of default was equity accumulation.

Swan argues that the methodology used by Vandell is invalid because it assumes that fixed rate mortgages and adjustable rate mortgages are influenced in the same way by equity accumulation, payment burden, and transient time factor. At this time Swan feels that there is no evidence to support such an assumption. He argues that Von Furstenberg's fixed rate mortgage studies[50] relied upon mortgage data collected at origination and not at the time of the incidence of default. Under fixed rate mortgages there is a predictable pattern of equity build-up associated with the monthly payments. This implies that the condition of the mortgage following origination should improve; i.e. equity should increase. ARMs do not provide a predictable pattern of equity accumulation. Therefore, studies based on the condition of a fixed rate

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[50] Von Furstenberg, George M. "Default Risk on FHA-Insured Home Mortgages as a Function of the Terms of Financing: A Quantitative Analysis." Journal of Finance, Vol. 24 (June, 1969), p.459-477.

mortgage at origination and not on the condition of the mortgage at the time of default, cannot be used to quantify the impact of ARMs on default risk.

Swan proceeds to recognize the importance of the fixed rate studies conclusions and uses them to deduce that ARMs, or any mortgage instrument that slows the accumulation of equity, will contribute to a higher incidence of default. Swan bases this deduction on the widely supported conclusions of fixed rate mortgage studies and the design characteristics of adjustable rate mortgages. Under periods of rising interest rates ARMs will have higher default rates due to increase in the payment to income ratio or due to less equity accumulation measured by higher loan to value ratios.

Trend and Shock

Trend and shock are important in the analysis of ARMs because they qualitatively measure the potential damage that a mortgage design may have upon a borrower's budget. Trend refers to the gradual increase or decrease in mortgage payments reflecting gradual changes in interest rates. Shock refers to sudden large changes in mortgage payments. The degree of trend or shock contained in a mortgage design is a function of the volatility of the related index, payment caps, adjustment interval and adjustment mechanism. The impact trend and shock have on borrowers is a function of the borrower's budget, consumption pattern and liquidity (savings).

Borrowers have a propensity to develop life styles based on disposable income. These lifestyles will accustom family members to

certain expenses during the course of a month. If the monthly mortgage payment increases, the non-mortgage expenses or savings will have to be reduced to avoid delinquency. The size of the increase in monthly mortgage payment will determine the amount of other consumption that needs to be foregone. If the increase is large, the burden on the family, measured by their sacrifice of normal expenditures will be great. If the increase is small, the burden will be small. Notice that the change in payment is what creates additional burden on the borrower. If the change is small, the borrower is able to adjust his budget by removing or reducing the slack (monthly contribution to savings). As long as the increased mortgage payment can be managed with budget slack, the borrower will not have to adjust his non-housing consumption pattern. If the change in mortgage payments exceeds budgetary slack, the borrower will have to reduce non-housing consumption, use accumulated savings, or not meet the mortgage obligation.

Which course of action the borrower takes is a function of the utility of non-housing consumption, housing consumption (meeting the mortgage obligation) and savings. If the marginal utility of housing consumption is greater than the marginal utility of non-housing consumption which is greater than the marginal utility of savings, the borrower reduces savings to meet the mortgage obligation. The borrower stops meeting the mortgage obligation when the marginal utility of savings and non-housing consumption exceeds the marginal utility of the mortgage expenditure. This condition is most likely to be met after an unexpected and large increase in the monthly mortgage payment, a shock.

This condition may also be the result of an upward trend in the mortgage payment. If the mortgage payment increases in small increments at each of several consecutive adjustment points, the burden of the mortgage payment may exceed the utility of the housing purchased. If this occurs the borrower will not meet the mortgage obligation. It should be noted that a gradual increase in the mortgage payment provides time and opportunity for the borrower to adjust his consumption pattern and increase his disposable income so that the burden of the mortgage does not exceed the utility of the housing. In general mortgage payment shock is far more harmful than mortgage payment trend.

The design of an ARM has a direct impact on the level of shock and trend the ARM possesses. Guttentag[51] has examined the relationship between various ARM contract provisions and their influence on mortgage payments. Eight contract provisions were examined and their impacts on mortgage payment instability, shock and trend were described. The eight traits were: frequency of rate and payment change, rate caps per period, payment cap per period, dual rates, volatility of index, partial rate changes and placing a maximum rate on the contract. Table 3.1 discloses Guttentag's conclusions. The contract provisions that are most likely to lead to mortgage payment shock are infrequent rate and payment adustments and less frequent rate adustment than payment adustment. ARMs with long adustment intervals have the capacity to maintain a stable monthly payment and contract rate while the index rate climbs. When the

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[51] Guttentag, Jack M. "Solving the Mortgage Menu Problem." Presented at ARUEA Mid-Year Meeting, Washington D.C. 1983.

adjustment period arrives, the difference between the contract rate and the index rate is substantial. The new contract rate is significantly higher than the old causing a large increase in the monthly payment. Had the contract rate risen as the index did, the monthly payment would be the same but the borrower would have adjusted to the higher payment over time. With a long period between adjustments, index rates can change significantly causing payment shock. If an ARM uses a rate index that has a shorter term than the adjustment interval, the potential for payment shock is enhanced. Shorter term interest rates have greater volatility than longer term interest rates. This volatility can translate into wide changes over an adjustment interval. The changes in the index are not reflected in the contract rate or mortgage payment until the end of the adjustment interval. This can cause payment shock because of the combination of a volatile index and a relatively long adjustment interval.

ARM Standardization

In the first first five months following the adoption of the Adjustable Mortgage Loan regulations by the Federal Home Loan Bank Board, the Federal National Mortgage Association purchased 120 different mortgage instruments in the secondary markets.[52] Guttentag,[53] Lea and

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[52] Maxwell,David. Remarks made at ABA Conference on Secondary Markets, May 2, 1983.

[53] Guttentag, Jack M. "Solving the Mortgage Menu Problem." Presented at ARUEA Mid-Year Meeting, Washington D.C. 1983.

Brown,[54] and Colton, Dougherty and Villiani[55] have questioned the impact that such diversity in mortgage designs may have on mortgage markets. Their concerns are directed toward the ability of mortgage markets to provide efficient trading in each variety of instrument.

Mortgages are originated in primary markets and traded in secondary markets. Each market is designed to achieve a different goal. The primary market allows borrowers and lenders to develop mortgage instruments that meet the needs of the two parties. The goal of the secondary market is to provide liquidity to mortgage lenders by providing buyers for mortgages of various designs. The method used to measure efficiency in the two markets is different because their goals are different. The primary market must provide a set of instruments that are readily comprehended and easily compared by borrowers and lenders. Currently, it is very difficult to compare and comprehend the wide variety of mortgage instruments. "With the multiplicity of instruments in the market today, confusion reigns even among many intermediaries such as real estate brokers..."[56] The confusion leads to dramatically increased information and investigation costs which according to

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54 Lea, Michael J. and Brown Carolyn. "ARM Pricing: Theory and Practice." Presented at AREUEA Mid-Year Meeting, Washington D.C., 1984.

55 Colton, Kent W. Dougherty, Ann J. and Villiani, Kevin E. "Optimal Design Charicteristics of Alternative Mortgage Instruments." Working Paper. May 26, 1983.

56 Guttentag, Jack M. "Solving the Mortgage Menu Problem." Presented at ARUEA Mid-Year Meeting, Washington D.C. 1983.p.5.

Guttentag decrease market efficiency. Lea and Brown[57] support for this position in their examination of the pricing relationships among various ARMs. They expected to find that instruments containing interest rate caps would have higher contract rates than those without interest rate caps. This was expected because interest rate caps cause the bearing of interest rate risk to be asymmetrical. Lenders bear a greater portion of the interest rate risk when rates are capped. They found that "there appears to be no significant difference between the average program rates on rate capped and non-rate capped programs."[58] This finding may be explained if it is accepted that interest rate risk is not born by lenders, Savings and Loans, but by taxpayers and the FSLIC.[59] This explanation, if accepted, would eliminate much of the argument associated with allowing the development of AMLs. Without this explaination, the findings of Lea and Brown are difficult to rationalize unless lenders fail to fully comprehend the implications of interest rate caps.

"Efficient secondary markets require substantial transaction volume in a given type of instrument. Large numbers of instruments fragment the market and raise secondary market transactions costs."[60] In order for

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57 Lea, Michael J. and Brown Carolyn. "ARM Pricing: Theory and Practice." Presented at AREUEA Mid-Year Meeting, Washington D.C., 1984.

58 Ibid.p.14.

59 Kane, E. "S & Ls and Interest Rate Reregulation: The FSLIC as an In-Place Bailout Program." Housing Finance Review, July, 1982.

60 Guttentag, Jack M. "Solving the Mortgage Menu Problem." Presented at ARUEA Mid-Year Meeting, Washington D.C. 1983.P.4.

secondary markets to be efficient, there must be sufficient stock and trading volume in substitutable instruments to give dealers confidence that they will be able to cover any and all short positions they may take. Without sufficient stock and trading volume, dealers will only take a short position if the price is substantially discounted to reflect their liquidity risk. Clearly, any instrument that lacks stock and volume will have a very wide bid-ask price range. This, according to Guttentag, is a sign of an inefficient market.

Guttentag feels that any instrument, to be traded efficiently, must have an outstanding stock of two billion dollars and annual trading volume of five hundred million dollars. The stock of conventional mortgages approaches one trillion dollars. If this stock is converted into adjustable mortgage loans there is enough volume to support efficient trading in five hundred instruments of the same size. It is highly unlikely that the instruments will trade with the same volume. Guttentag argues that limiting the number of mortgage designs to fifty will insure that all instruments are traded in efficient markets. This limit should provide ample flexibility to mortgage originators, yet maintain efficient primary and secondary markets.

The arguments for standardization are formidable. The primary type of standardization sought is mechanical. That is, all instruments allowing negative amortization should calculate negative amortization in an identical manner. All instruments having variable payments with caps should use the same mechanics to determine when the cap is reached and what occurrs to the difference between the payment limit and what the unlimited payment would be. Under some instruments, this amount is

treated as negative amortization and the loan balance increases. Under others, the term of the mortgage is extended and still others ignore the difference. Guttentag maintains that if all instruments used the same mechanics, operational definitions, the number of mortgage designs would be dramatically reduced without eliminating significant flexibility in the design of instruments.

Table 3.1

Relationship of Various Contract Provisions of ARMs to Major Concerns of Borrowers Regarding Mortgage Payment Uncertainty[61]

Contract Provisions	Mortgage Payment Instability	Shock	Trend
Infrequent rate and payment adjustments	+	-	0
Maximum rate change per period	+	+	0
Less frequent rate adjustment than payment adjustment	+	-	0
Cap on payment change per period	+	+	0
Separate rate for payment and balance	+	+	0
Sluggish rate adustment	+	+	0
Partial rate adjustment	+	+	+
Maximum rate change per contract	0	0	+

Note: + means the provision helps; - means it hurts; 0 means it is neutral

[61] Guttentag, Jack M. "Solving the Mortgage Menu Problem." Presented at ARUEA Mid-Year Meeting, Washington D.C. 1983.P.4.

Chapter IV

The Risk Measurement Model

The evaluation of the impact of various mortgage provisions upon mortgage risks is accomplished by developing surrogate measures for each of the traditional mortgage risk categories and calculating the influence that various mortgage provisions have upon the risk measures. The surrogate risk measures are; Potential Call Losses (PCL), Potential Put Losses (PPL), Potential Delinquency Losses (PdL), Conditional Default Losses (CDL), Conditional Default Gains (CDG), Potential Default Losses (PDL), and Potential Market Losses (PML). The Potential Losses are used to measure two aspects of mortgage risk: the size of the loss, and the probability of the loss occurring. In order to understand the impact of a mortgage design upon the level of risk exposure of the lender, the size and probability of a loss must be known. Both of these elements of expected loss must be known for a lender and borrower to properly access the utility of a mortgage design. Ignoring either the probability or loss size may cause a higher utility to be associated with a mortgage design that has a low probability of reaching a loss condition, but an extremely high loss value, than a mortgage with a slightly higher probability of reaching a loss condition, but a low loss value. Any evaluation of mortgage instrument risk must consider both the size of the loss exposure and its probability. The Potential Losses provide a measure of the size of a potential loss to lenders due to each type of risk. The probability of loss is calculated by finding the percentage of iterations that incur the potential loss in a simulation

model. This is explained in detail later in this paper.

The Potential Losses consist of two essential pieces: the triggering event, and the loss. The triggering events for each Potential Loss are the conditions that must exist in order for a rational borrower to pursue a course of action that results in a loss condition for the lender. The existance of these conditions does not necessitate a loss condition in a real world setting, but if the conditions are not meet, any loss must be due to irrational economic behavior on the part of the borrower. The second component of a Potential Loss is the size of the loss. This represents the dollar loss that would be incurred by the lender if the borrower proceeded with the course of action suggested by the triggering event. These actions include: delinquency, default, prepayment, and postponement of terminal payment. For each of the Potential Losses the triggering events are discussed and the loss calculation is disclosed.

Potential Default Losses

Potential Default Losses (PDLs) are used to measure the impact of various mortgage provisions upon lenders exposure to losses that are the result of rational economic default. Rational economic default is defined in an option framework as a mortgage that is out of the money. The dollar loss incurred by the lender when a mortgage is out of the money is the difference between the net proceeds the lender can collect through foreclosure and the value of the mortgage.

The triggering events for rational economic default are based on

the determinants of default and the value of the mortgage to the borrower. The value of a mortgage to the borrower is determined using an option framework. The mortgage is viewed as a thirty day call option, granting the borrower the right to purchase the house at the exercise price. The exercise price is a function of the loan balance, call premium and mortgage value. Mathematically:

$$\text{Exercise Price} = \text{Loan balance} + \text{Call} - \text{Mortgage value}$$

where: Loan balance is the remaining balance on the mortgage, Call is the call premium expressed in dollars, and Mortgage Value is the difference between the present value of the current mortgage payments and those of an identical mortgage with the current market coupon rate plus the present value of the difference in the remaining balance at the end of the current adjustment period or the expected termination date, whichever occurrs first. Each month the borrower can pursue any of three options. He can exercise the option and purchase the house by prepaying the mortgage. He can renew the option for another thirty day period by making the monthly payment. Or, he can do nothing and allow the option to expire. The latter course of action is equivalent to default. Which option he pursues is a function of the relationship between the exercise price of the option and the value of the house.

To a rational borrower the value of the house is its market value less selling costs (7%) plus moving costs, direct and indirect, plus the

increase in future credit costs due to default. Foster and Van Order[62] assumed that the moving costs plus the increase in future credit costs would be equal to 10% of the market value of the house. Their assumption will be followed here. Mathematically:

$$\text{Value} = 0.93 * (\text{Value of house}) + 0.1 * (\text{Value of house})$$

Rational economic default only occurs if the exercise price exceeds the value of the house plus the monthly mortgage payment. This condition is consistent with the primary determinant of mortgage default, high loan to value ratios, found by Herzog and Earley[63] and other researchers. When the conditions for rational economic default exist it is assumed that the default occurs. This may not be the case under actual conditions, but all rational borrowers consider the default option to be a viable alternative when these conditions are met. The actual decision to default has many aspects not examined here. This model only considers the conditions necessary for default that are influenced by mortgage design.

Once the conditions for rational default are met and the borrower has defaulted, one of several loss determining events occur. First, the lender may take possession of the house and sell it for its market

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[62] Foster, Chester and Van Order, Robert. "An Option-Based Model of Mortgage Default." Working Paper. U.S. Department of Housing and Urban Development. 1984.

[63] Herzog, John P. and Earley, James S., Home Mortgage Delinquency and Foreclosure, National Bureau of Economic Research Number 91, General Series. Columbia University Press, 1970, New York.

value. If this occurs the lender receives the market value of the house less selling expenses, typically 7%. This amount is credited against the loan balance. If the loan balance is less than the net selling price of the house, the lender must pay the excess to the borrower. If the net sales proceeds are less then the loan balance, the lender may sue the borrower for the shortage, or, if the loan is insured, file a claim with the insurer. If the borrower has available funds in excess of the shortage, or, the insurance covers the shortage and an award is made or claim is paid, there is no loss. If there is no insurance and the borrower has no funds available, the lender suffers a loss equal to the difference between the net selling price and the loan balance. The lender may also be the victim of opportunity losses and gains. Opportunity losses occur when the defaulting mortgage coupon rate is higher than the prevailing mortgage market required rate of return. The value of this loss to the lender is the present value of the difference between the defaulting mortgage payments and those of a mortgage that is identical to the defaulting mortgage except that it carries the current mortgage market coupon rate plus the difference in the remaining balance of the two mortgages at the earlier of the expected termination date or the end of the current adjustment interval. The opportunity loss must be added to the difference between the net selling price and the loan balance. If the defaulting mortgage has a coupon rate that is lower than the current mortgage market rate, the lender has an opportunity gain equal to the present value of the difference between the defaulting mortgage payments and those of a mortgage that is identical to the defaulting mortgage in all parameters except the coupon rate plus the

difference between the remaining balances of the mortgages at the earlier of the expected termination date or the end of the current adjustment interval. The opportunity gain must be netted against the difference between the sales price and the loan balance.

Assume a mortgage with a remaining balance of $50,000, a remaining term of twenty years and a contract rate of twelve percent is defaulted on. This mortgage has twenty-four months remaining in the current adjustment interval and the market required contract rate for similiar mortgages is ten percent. The lender suffers an opportunity loss because the proceeds form the default will be reinvested to earn ten percent instead of the twelve percent the defaulting mortgage is paying. The opportunity loss to the lender is equal to:

$$\text{Opp.Loss} = \sum_{t=i}^{n} (P_t - MP_t) / (1 + R)^t + (B_o - B_m)/(1+R)^n$$

where P_t is the defaulting mortgage's payment in month t, MP_t is the payment of a similiar mortgage with the market required contract rate, R is the market required contract rate, B_o is the remaining balance at the earlier of the end of the current adjustment interval or the expected termination date of the defaulting mortgage, B_m is the remaining balance of the market mortgage at the same point, and n is the number of months until the earlier of the expected termination date or the end of the adjustment interval. The opportunity loss in the above example is $1852.99. The difference in the monthly payment is $68.00 per month for twenty four months and the difference in the remaining balance at the

end of the current adjustment interval is $387.00. The opportunity loss or gain is included in the lender's default loss in the following manner:

Def Loss = Net Sales Price - Loan Balance + Opp. Gain - Opp. Loss

The above loss can occur at any point in the life of a mortgage. Due to the time value of money, losses that occur at different points in the life of a mortgage are not directly comparable. To assure that the Potential Default Losses from different mortgage instruments are directly comparable, their values are adjusted to the origination date of the mortgage using the following formula:

$$PDL = \text{Def Loss} \; / \; [1 + (\sum_{t=1}^{n} D_t) \; / \; n]^n$$

where: n is the number of months between origination and default, D is the market required rate of return for instruments with the same design and Def Loss is as defined above. PDLs measure the size of lender losses due to rational economic default at the origination date. This measure is used to compare the sensitivity of various mortgage designs to default risk.

Potential Delinquency Losses

Potential Delinquency Losses (PdLs) are based on the delinquency studies done by Herzog and Earley,[64] Jung, and Webb[65]. All of these studies have linked the occurence of delinquency with the level of the payment to income ratio. PdLs serve as a surrogate measure for the opportunity loss that a lender incurs when a mortgage payment is made late. As with Potential Default Losses, the model only attempts to analyze rational responses to changes in the financial condition of a mortgage and does not examine delinquencies due to human error or non-economic circumstances.

The key issue in delinquency is when does a rational borrower elect to delay making his mortgage payment. From the literature it appears that this election is made when the payment burden becomes greater than the utility of making the payment in a timely fashion. The payment to income ratio has been widely accepted as a surrogate measure for payment burden and is used here as the triggering event. Table 4.1 shows the relationship between the payment to income ratio and the rate of delinquency between 1973 and 1983. Notice that the level of delinquencies increase when the payment to income ratio reaches 29%. To determine if 29% is a critical level for delinquency, the sample was split into two subsets: observations with payment to income ratios of

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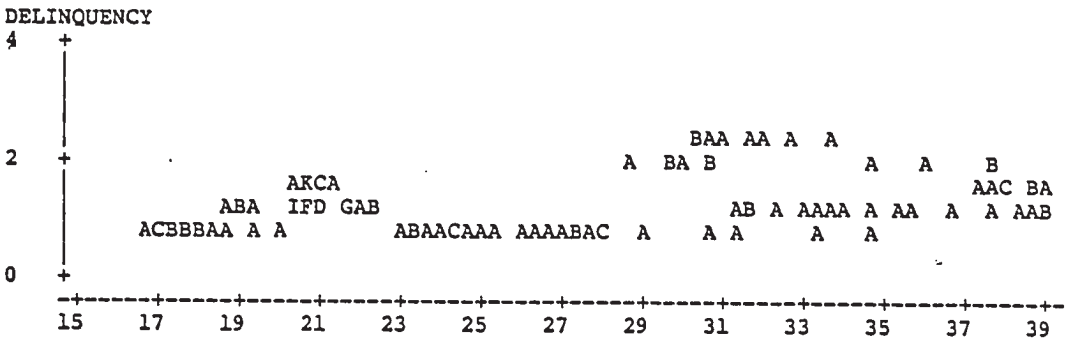
[64] Jung, A. E. "Terms of Conventional Mortgage Loans on Exsisting Houses." Journal of Finance. Septemner, 1962.

[65] Webb, Bruce G. "Borrower Risk under Alternative Mortgage Instruments." Journal of Finance. March, 1982.

Table 4.1

Plot of monthly delinquency rates and payment to income ratios from January, 1973 to December 1983.

PLOT OF DEL*PTI LEGEND: A = 1 OBS, B = 2 OBS, ETC.



T-TEST for difference in means between the delinquency rate in months with a payment to income ratio of less than or equal to 29% and those with a payment to income ratio of greater than 29%.

T-TEST PROCEDURE

VARIABLE: DEL

A	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM
PTI<29	85	1.13682353	0.25595392	0.02776210	0.83000000	2.15000000
PTI>29	47	1.59127660	0.48809575	0.07119608	0.91000000	2.36000000

VARIANCES	T	DF	PROB > |T|
UNEQUAL	-5.9470	60.3	0.0001
EQUAL	-7.0257	130.0	0.0001

FOR H0: VARIANCES ARE EQUAL, F'= 3.64 WITH 46 AND 84 DF
PROB > F'= 0.0001

less than 29% and those with payment to income ratios greater than or equal to 29%. The two subsets were compared using a standard T-test to determine if their means were the same. The results of the test indicate that the data subset with a payment to income ratio of greater than or equal to 29% has a significantly larger mean than the other subset with a p-value of less than 0.001. This implies that there is a significant difference in borrower behavior when the payment to income ratio reaches 29%. The mean of the data subset with the higher payment to income ratios is 34%. Therefore, it is assumed that a borrower does not meet his monthly mortgage payment any time the payment to income ratio equals or exceeds 34%. A payment to income ratio of 34% or greater is the triggering event for Potential Delinquency Losses (PdLs). The surrogate measure for the delinquency loss incurred by the lender is the monthly payment. In a real world situation the loss is better described as an opportunity loss caused by foregoing the reinvestment income on the missed payment less any late fees that the lender is able to collect from the borrower. Notice that this amount is directly proportional to the size of the monthly payment (assuming late fees are a percentage of the monthly payment). The monthly payment serves as an accurate surrogate measure for delinquency losses. Potential Delinquency Losses continue to accumulate until the payment to income ratio falls below 34% or three months pass. At the end of three months if the payment to income ratio is not below 34% the lender is assumed to foreclose on the loan and a Conditional Default Loss or Gain is incurred. Conditional Defaults are explained later in this paper. PdLs measure the value of the missed payments at the time of mortgage origination using the

average market required rate of return as the discount rate. The actual loss measure for Potential Delinquency Losses is:

$$PdL = \sum_{t=t}^{n} [\ Pay_t / (1+D)^t\ ]$$

where; Pay_t is the payment missed in month t, D is the average monthly mortgage market required rate of return over the period from origination to t for the instrument being examined. The PdL measures the potential size of the loss incurred by lenders when borrowers fail to make timely mortgage payments, but avoid foreclosure by making a payment within three months. Borrowers are assumed to become delinquent only when the payment to income ratio reaches or exceeds 34%.

Conditional Default Gains and Losses

Conditional Default Gains (CDG) and Losses (CDL) are special cases of Potential Delinquency Losses. The only time conditional losses or gains are incurred is when the payment to income ratio remains above 34% for three months. When this occurs the borrower has failed to make three mortgage payments and the lender is assumed to foreclose on the property. The lender sells the property and realizes a gain or loss depending on the net proceeds realized from the sale of the property, the opportunity value of the mortgage, and the remaining balance of the mortgage. Mathematically:

Alpha = Net Sales Price - Loan Balance + Opp. Gain - Opp. Loss

where: Alpha is a Conditional Default Gain when positive and a Conditional Default Loss when negative, the net sales price is ninety-three percent of the home's value, the loan balance is the remaining balance of the mortgage, the opportunity gain or loss is the present value of the difference between the payments and the remaining balance at the earlier of the end of the adjustment interval or the expected termination date of the outstanding mortgage and those of a similiar mortgage with the current market required coupon rate. When the market required coupon rate exceeds that of the outstanding mortgage a gain is recognized and a loss is recognized when the coupon rate on the outstanding mortgage is higher than the current market required coupon rate. Conditional Default Gains and Losses are the present value of their respective Alphas at the origination month of the mortgage. Mathematically:

$$CDG = Alpha_G / (1 + D)^t$$

and

$$CDL = Alpha_L / (1 + D)^t$$

where: D is the average market required rate of return for similiar mortgage instruments over the period from origination to the month of default, and t is the number of months between origination and default. CDLs and CDGs for various instruments are directly comparable across mortgage designs and measure the impact on lenders of foreclosures caused by increases in the payment burden of a mortgage.

Potential Call Losses

Potential Call Losses are used to measure the impact of various mortgage provisions upon the implied losses associated with a rational mortgage call prior to the expected termination date. A rational mortgage call is defined here as a mortgage prepayment that is precipitated by a decline in interest rates and is part of a refinancing operation that yields economic benefits to the borrower. Naturally, the prepayment must occur prior to the anticipated mortgage termination date or it would not be a prepayment in the economic sense. The anticipated date is not the same as the stated maturity date. The anticipated date is the expected length of time the lender assumes the mortgage will be outstanding. Borrowers exercise their call options when they derive economic benefits from refinancing. The benefits to the borrower are highly correlated to the implied losses of the lender.

Rational economic calls occur whenever the borrower's benefits from refinancing exceed his costs. The costs of refinancing include the prepayment penalty or call premium on the old mortgage and the closing costs on the new mortgage. The closing costs on the new mortgage are assumed to be two percent of the initial loan balance of the new mortgage. The initial loan balance is assumed to be remaining balance of the old mortgage plus the call premium paid on the old mortgage. This means the costs associated with refinancing are:

$$Cost = Call * B + Close * (B *(1 + Call))$$

where: B is the remaining balance on the old mortgage, Close is the

assumed closing cost of two percent of the new mortgage balance, and Call is the percentage cost to call the old mortgage. The benefit associated with refinancing is measured by the difference in the monthly mortgage payment between a mortgage with the current market required coupon rate and the old mortgage. Mathematically:

$$\text{Benefit} = \sum_{t=1}^{n} [\ (\text{Old}_t - \text{New}_t)\ /\ (1 + R)^t\ ] + \text{Diff}$$

where: Old_t is the monthly mortgage payment in month t of the mortgage to be called, New_t is the mortgage payment of the replacement mortgage in month t, R is the market required rate of return, n is the number of months until there is no difference in the payment stream of the two mortgages, and Diff is the present value of the difference between the remaining balance of the called mortgage and the new mortgage at the next interest rate adjustment point of the old mortgage. It is assumed that the only difference between the new mortgage and the one being called is the size of the coupon rate. Both mortgages consist of the same provisions and the same mandatory termination date. This assumption eliminates mortgage design swapping from consideration. There are two reasons for this. First, to consider swapping opens an unlimited number of possiblities and requires that the borrower forecast interest rates in order to choose the optimal mortgage design. It is highly unlikely that borrowers have the capacity to forecast interest rates with enough accurracy to make their rewards worth their efforts. It is also assumed that borrowers choose a particular mortgage design because its

provisions have an intrinsic value to the borrower. When the borrowers refinance, it is assumed that his preferences have not changed so he refinances with the same mortgage design.

The necessary conditions for refinancing are met if the benefits of refinancing exceed the costs of refinancing. When this occurs the lender's loss is:

$$PCL = \left[\sum_{i=1}^{n} (P_i - MP_i)/(1+R)^{t} + Diff - .03 * B \right] /(1+D)^{m}$$

where: P is the mortgage payment of the old mortgage, MP is the monthly payment of the new mortgage, n is the number of months over which the payments are different, R is the market required rate of return on mortgages with the same design as the mortgage being called, Diff is as defined above, B is the remaining balance, D is the average market required rate of return on similiar mortgage instruments over the period from origination to month m, and m is the number of months the old mortgage has been outstanding. The PCL measures the loss that is incurred by the lender if the borrower refinances his home when the necessary conditions for refinancing are present. Borrowers may not refinance when the benefits exceed the costs outlined here because of the effort involved in determining the benefits and costs associated with refinancing. The PCL measures the potential lender losses due to refinancings based on the necessary conditions for rational refinancing.

Potential Put Losses

Potential Put Losses measure the impact on lenders of a rational extension of the life of a mortgage beyond the expected termination date. Rational extension occurs when the mortgage coupon rate is lower than the prevailing market determined coupon rate for mortgages with similiar provisions. The borrower elects to continue to service the mortgage obligation by making the required monthly payment instead of prepaying the mortgage. The lender's loss is an opportunity loss. If the borrower prepaid at the expected termination date the lender would be able to reinvest the proceeds at the market rate of return. Therefore, the loss to the lender is the present value of the difference between market mortgage payments and those of the outstanding mortgage after the expected termination date. Mathematically:

$$PPL = \sum_{t=1}^{\infty} (M_{m+t} - P_{m+t}) / (1+d)^{m+t}$$

where: M_{m+t} is the market determined mortgage payment in month m+t, P_{m+t} is the outstanding mortgage's payment in month m+t, d is the average required rate of return for similiar mortgages from origination to month m+t, and m is the expected termination month. A PPL only assumes value if the borrower continues to service his mortgage after the expected termination date. This is assumed to ocurr if the necessary conditions for rational mortgage extension exsist (the coupon rate of the mortgage is lower than the market required coupon rate).

Potential Market Losses

Potential Market Losses are a surrogate measure for the market or interest rate risk of mortgage instruments. As interest rates vary, the market price or value of a mortgage instrument changes. This change is a function of the instrument's coupon rate and its term to maturity. In the case of fixed rate mortgages the coupon rate is set until the mandatory termination date. Adjustable rate mortgages have a coupon rate that is set until the next adjustment point. If the coupon rate is adjusted to the prevailing market required rate of return at the adjustment point the value of the mortgage is at parity with the remaining balance at the adjustment point. It is assumed that the coupon rate is adjusted to the market required rate of return unless the instrument design restricts the movement of the coupon rate. The potential loss for a lender is the difference between the market value of a mortgage and the remaining balance of the loan. The market value of a fixed rate mortgage is found by calculating discount points and then applying them to the balance of the mortgage. Mathematically:

$$DP = 1 - \left((1-(1/((1+R)^{T})))/R\right)*\left(1/((1-(1/(1+c)^{t})))/c\right) - (1/(1+R)^{T})*(1-(1/((1+c)^{t-T}))/(1-1/((1+R)^{t}))$$

where: DP is the discount points, R is the market required rate of return, T is the number of months until the expected termination, c is the mortgage's coupon rate, and t is the number of months until mandatory termination. The market value of the loan is calculated by

multiplying 1 - DP times the remaining balance of the loan. This mortgage pricing technique only works for fixed rate mortgages. For adjustable mortgage loans, the pricing technique requires modification. A primary reason that fixed and adjustable loans cannot be priced in the same manner is that adjustable mortgage loan prices are at parity with the remaining balance at each adjustment point (assuming there are no restrictions on the contract rate). This means that the cashflow stream from an adjustable mortgage loan changes. Securities are viewed for valuation purposes as cashflow vectors. Anything that alters the cashflow vector changes the security. Therefore, adjustable mortgage loans create a security at each adjustment period that does not have the same cashflow vector as it did over the previous adjustment interval. This causes the value of the adjustable rate mortgage to change at the end of each adjustment interval. Adjustable mortgage loans are priced by calculating the present value of the payment stream until the adjustment period and the balance at the adjustment period. The discount rate is the market required rate of return.

$$\text{Price} = \sum_{t=1}^{n} (P_t / (1+R)^t) + B / (1+R)^t$$

where: Price is the market value of the loan, n is the number of months until the next adjustment interval, P_t is the mortgage payment in month t, R is the market required rate of return on similiar mortgages, and B is the remaining balance at the next adjustment point. This formula is equivalent to the result obtained using the discount point method used for fixed rate mortgages if the expected termination date is

set equal to the next adjustment interval. In other words, Adjustable Rate Mortgages that do not have limited contract rate movements impose an assumed prepayment date equal to the next adjustment point upon market valuation calculations. It should be noted that the price of a loan is limited to the mimimum sum at which anyone is able to purchase the loan. In other words, because the borrower can exercise his call option, the maximum price on a mortgage loan is the remaining balance plus the call premium.

The Potential Market Loss is the sum of the values of the discount points used to determine the market value of a mortgage at the mortgage's origination date. For Adjustable Rate Mortgages the discount points are calculated by the following formula:

$$DP = (\text{Remaining Balance} - \text{Price}) / \text{Price}$$

where: Price is the price of the mortgage as defined above. The Potential Market Loss is:

$$PML = \sum_{t=1}^{n} (DP_t / (1+D)t)$$

where: DP_t is the discount points required to adjust the balance of the mortgage to its market value in month t, and D is the average market required rate of return for similiar mortgages from the month of origination to month t.

All of the potential loss measures are used to measure the exposure to a particular category of loss inherent in a mortgage design. None of the measures are direct. Each is a surrogate that demonstrates the size a loss that is incurred by a lender when the necessary conditions for a

rational loss occur. These measures are not perfect, but serve to measure the differences in the risk exposure levels associated with various mortgage provisions.

Chapter V

Methodology

In the previous section a set of surrogate risk measures are explained. These measures are implemented using Monte Carlo experimentation. Monte Carlo experiments are a technique that allows the surrogate risk measures to be calculated using preassigned parameters and random numbers for the disturbances.[66] This method is used because of the lack of experience data for adjustable mortgage loans. The key elements to the Monte Carlo experiment are the impact of various adjustment intervals and related interest rate series on the contract rate of the mortgage, the relationships between the contract rate of a mortgage and its monthly payment, remaining balance, and remaining term, the triggering events of the potential losses, the disturbance terms, and the comparison of the Potential Losses. Mathematically the experiment can be described as:

$$PL_n = MD_m + TE_n + DT$$

where: PL_n is the n^{th} Potential Loss, n implies one the seven Potential Losses; MD_m is the m^{th} mortgage design under examination, TE_n is the triggering event for the n^{th} Potential Loss, and DT is the set of disturbance terms. The triggering events for each of the Potential

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[66] Christ,C.F. Econometric Models and Methods. John Wiley & Sons. New York, New York. 1966. pp. 474-481.

Losses are described earlier in this paper. The mortgage designs are broken into three categories: variable payment, variable balance, and variable term. Under each category there are three instruments distinguishable only by differing related indices and adjustment intervals. The disturbances terms consist of four interest rate series, the house value series and the income series.

All of the mortgage designs examined have a common set of parameters that are listed in Table 5.1. The initial contract and market rate is the same for all mortgage designs. In practice adjustable mortgage loans generally have a lower contract rate than fixed rate mortgages. The size of the difference varies depending on who the lender is, the specfic instrument design and the time of the mortgage origination. In this experiment, the size of the initial contract rate is not as important as how the rate changes and the instrument's response to the change.

Further, it is imparative that all mortgages used in the experiment begin in the same condition, measured by the payment to income and loan to value ratios. These ratios are a function of the house value, initial loan balance, initial term to maturity, mortgage contract rate, and the monthly income of the borrower. Altering any of these terms would cause the initial condition of the mortgage to be altered. Therefore, all mortgage designs begin with the same contract rate, term to maturity, house value, and initial loan balance. The initial loan to value ratio for all mortgage designs is ninety percent. The initial payment to income ratio for all mortgage designs is thirty-two percent.

The relationships between the contract rate, monthly payment,

remaining balance and remaining term are a function of the three fundamental mortgage provisions. No limitations or caps are considered so that the full impact of different adjustment mechanisms and intervals is measured. All of the adjustable mortgage designs are subject to the mandatory five year payment adjustment interval. Every five years all adjustable rate mortgages are examined to determine whether or not their remaining balances will be fully amortized by their mandatory termination date, not more than four hundred and eighty months from origination, at their current contract rate. If the remaining loan balance cannot be fully amortized by then, the monthly payment is increased, regardless of the mortgage design. In essence this mandated provision turns all adjustable mortgage loans into conditional adjustable payment mortgages with five year intervals.

There are two conditions that can cause a mandatory increase in the monthly payment. Both require an increase in the contract rate of the mortgage without a full payment adjustment. If a mortgage has experienced negative amortization it is possible for the remaining balance to be too large to be fully amortized by the mandatory termination date even if the current contract rate is lower than the initial contract rate. Assume an adjustable balance mortgage with a one year adjustment interval is in its fourth year. Its initial contract rate was ten percent. At the one year adjustment interval the contract rate increased to fifteen percent and has remained at that level. This generates negative amortization (i.e. the remaining balance of the loan is growing). In the fifth year the contract rate falls to nine percent.

If the amount of negative amortization has increased the remaining balance to one hundred and five percent of the remaining balance when the negative amortization began and the initial term was thirty years, the monthly payment has to increase or the loan will not fully amortize. Negative amortization can cause mandatory payment increases.

The second cause of mandatory payment increases is an increase in the contract rate of the mortgage in the fifth year without a change in the monthly payment. Assume an adjustable balance mortgage has maintained the same contract rate for four years. In the fifth year the contract rate increases. The increase causes a slowdown in the amortization od the balance of the mortgage. The slowdown implies a balloon payment on the termination date. Unfortunately, the mortgage must be examined for mandatory payment increases. The conditions for a mandatory increase are present so the payment is changed. Increases in the contract rate of a mortgage close to the mandatory payment increase examination can cause payment increases.

All of the mortgages examined are pure in design. The variable payment mortgage is a pure variable payment mortgage. There are no allowances for negative amortization or extension of the mortgage term under this instrument. The variable balance mortgage provides for changes in the amount of the payment that is credited against principal in response to changes in the contract rate. The variable term mortgage allows the term of the mortgage to increase to four hundred and eighty months from the point of origination in response to changes in the contract rate. Once the term has reached four hundred and eighty months, the amount of payment applied to principal is adjusted to reflect

further increases in the contract rate. Under the variable term and balance mortgages, negative amortization is unrestricted. All of the instruments being examined are designed to isolate the impact of their adjustment mechanisms upon mortgage risks.

Three adjustment intervals are imposed on each of the adjustable mortgages. The intervals chosen for examination are one, three and five years. The related interest rate series for each interval are the adjusted maturity yield series kept by the Federal Reserve with a maturity that matches the adjustment interval. For one year adjustments, the yield on one year adjusted maturity treasury notes is used. For three year adjustments, the yield on three year adjusted maturity treasury notes is used and for five year adjustments, the five year adjusted maturity treasury note yields are used. When mortgage designs match the maturity of the index to the adjustment interval, the mortgage converts the interest rate risk of a long term security into the interest rate risk of security with a maturity approximating that of the adjustment interval. In essence the lender is shifting the position of the loan to the left on a yield curve and accepts the interest rate risk associated with the mortgage's new position on the yield curve.

If the mortgage design calls for an index whose maturity differs from the length of the adjustment interval, the mortgage is a way of speculating on the shape of the yield curve. If the index has a longer maturity than the adjustment interval and the yield curve is positively sloped, the lender profits. If the yield curve is negatively sloped through the relevant range, the lender suffers an opportunity loss.

Speculative mortgage designs are not consistent with the original purpose of Adjustable Mortgage Loans and therefore are beyond the scope of this work. All of the examined adjustable mortgage loans have an adjustment interval that matches the maturity of the associated index.

The disturbance terms for the experiment consist of four interest rate series, house values, and income levels. All of the disturbance terms change values on a monthly basis. The stochastic properties of the distributions of the disturbance terms are based upon each term's distribution between January of 1971 and December of 1983. For each disturbance term, the historic series was collected and its distribution identified. In all cases a simple transformation yields a series that is not significantly different from normal. Table 5.2 reveals the tranformations and Z statistics from the Kolmogornov-Smirnoff test for normal, the mean, and standard deviation. The parameters of the distributions of the transformed series reveal that all of the series have a slight upward bias.

The key element of the Monte Carlo experiment is the computer simulation program. The program calculates the response of mortgages to changes in the disturbance terms. The program measures the response of mortgage instruments by calculating the Potential Losses associated with each instrument. The simulation program's most important component is the simulation of the disturbance terms. Other components include: calculating the monthly payment, balance and remaining term of the mortgage instrument; checking the condition of the mortgage against the triggering events of the Potential Losses; calculating the Potential Losses; and calculating the internal rate of return on the mortgage. The

output of the computer simulation program is a set of data consisting of five hundred observations. Each observation contains the values for the Potential Losses, the month in which the simulated instrument terminated, and the internal rate of return of the mortgage. These data sets are analyzed using two statistical techniques to be discussed later.

The actual interest rate data is described in terms of four parameters: percentage change distribution, minimum and maximum absolute change, correlation between the sign of adjacent monthly changes, and a minimum and maximum value. These parameters are used to simulate the required interest rates. The dominate consideration in the simulations is the distribution of the percentage changes. Table 5.2 reveals that the distribution of the percentage changes in each of the interest rate series is not significantly different from zero at the 0.01 level. The mean, standard deviation, absolute maximum and minimum change, and correlation between the direction of subsequent changes are also shown. The mean and standard deviation are used as the primary parameters of a normal distribution estimating equation. Mathematically:

$$V = (A - 6.0) * STD + MEAN$$

where: V is the percentage change in the interest rate series, STD is the standard deviation of the percentage changes of the transformed series, MEAN is the mean percentage change of the transformed series, and A is the semi-random seed. The value for A is selected to maintain the short term trend found in the actual series. This is done

restricting the range of the potential values of A according to the short term trend of the series. Assume that the short term trend is positive and the probability of the trend continuing is seventy percent. The potential range of A is selected so that the corresponding value of V is greater than one seventy percent of the time. After V is calculated and multiplied by the previous month's interest rate to yield the new interest rate, the absolute change and size of the interest rate are examined. The change between the interest rates of any two consecutive months is constrained to a range. If the change lies outside this range the new month's rate is reset so that the change equals its boundry. The last step in determining any month's interest rate is to insure that it lies within its absolute range. For each of the interest rate series a minimum and maximum value are given in Table 5.2. If the new value lies outside this range it is reset to the closest boundry. The stochastic processes governing the simulation of each of the interest rate series reflect the percentage changes, absolute changes, short term trends and absolute range of the actual series between 1971 and 1983.

The house value and income level simulations are accomplished by using a normal distribution generator to simulate a transformed series of the actual data. The transformation of the housing values is a simple percentage change (H_{t+1} / H_t). The income series is simulated using the natural log of the income level in period t divided by the natural log of the income level in period t-1. There are no constraints placed on the simulated values.

The values for the Potential Losses of various mortgage designs are

determined by a Monte Carlo experiment. The experiment is broken down into a macro and micro flow chart. The macro flow chart is presented in Table 5.3 and the micro flow chart is presented in Table 5.4. The macro flowchart reveals the steps that are taken to conduct the experiment. The micro flow chart reveals the steps that are taken to simulate the performance of a mortgage in each month of its life.

There are ten steps in the macro flow chart. The first is to initialize the parameters of the disturbance terms. In this experiment two sets of disturbance terms are used. The first is based on historic data between 1971 and 1983. This set is discussed above and is labled the upward biased set. The second set of disturbance terms is a modification of the first. The mean of the percentage changes of each of the disturbance terms is set to one. This second scenerio is labled the neutral set. All of the other parameters of the stochastic prosesses governing the disturbance terms remain unchanged. This step is repeated repeated twice.

The second macro step is to establish the mortgage design to be examined. There are four basic designs that can be modified in several ways. The fixed rate mortgage is the first mortgage examined. Its adjustment interval is set to four hundred and eighty one months. This eliminates the possibility of any changes in its contract rate. Then the adjustable payment, balance and term mortgages are examined. For each of these mortgages three different adjustment intervals are used. Three additional adjustable payment mortgages are examined. These mortgages are identical to the other adjustable payment designs except that they

have a seven and one half percent per period payment change cap. Thirteen different mortgage designs are examined.

The next macro step is to invoke the micro flowchart. This is the actual monthly simulation of the mortgage designs. The first step in the micro flowchart is to set the initial mortgage parameters. These parameters are listed in Table 5.1. The parameters represent the condition of each mortgage design at origination. The next micro step is to check the adjustment interval to determine if a monthly payment needs to be calculated. In month of origination the monthly payment is calculated for all mortgages. At all other times the monthly payment is calculated if a new adjustment interval is beginning and the mortgage is an adjustable payment or the mandatory payment adjustment conditions are meet. The next step is to calculate the monthly payment using the market required contract rate. This sum is used in the Potential Loss calculations. The Potential Losses are checked for next.

The first set of Potential Losses examined are related to delinquency. Potential Delinquency losses are only incurred if the payment to income ratio equals or exceeds thirty-four percent. If this condition is meet for three consecutive months the loan is placed in Conditional Default and terminated. The program summarizes this iteration. Otherwise, Potential Call Losses are checked for. If the benefits of refinancing exceed the costs of refinancing the mortgage is called and the Potential Call Loss is calculated. This is a terminal event so the program advances to the summary stage. The next Potential Loss is the Put Loss. This loss can only be incurred if the current month of the mortgage's life is greater than the expected termination

date. Potential Put Losses are not terminal so the program continues by checking for Potential Default Losses. If the conditions for a rational default are present the Potential Default Losses are calculated and the mortgage iteration is summarized. The last Potential Loss is the Potential Market Loss. This is calculated in each month of the mortgage's life.

The final steps of the micro flow chart update the disturbance terms and the remaining balance. Then the mortgage is examined for normal termination. If the the month of the mortgage is greater than or equal to the expected termination date and the market required contract rate is lower or equal to the mortgage's contract rate themortgage terminates normally. The program branches to the summary step and the iteration is summarized. If the mortgage is not ready for termination the program branches to the check interval step, updates the month and repeats the process.

The summary step consists of two components. First, the program calculates the internal rate of return for this iteration of the mortgage design. Then the program records all of the Potential Loss values, internal rate of return and termination month for the iteration in a data set. It should be noted that the Potential Losses that lead to the summary step are mutually exclusive. That is, if a Conditional Default is incurred, no further losses are calculated for that iteration. The mutually exclusive losses are Conditional Default, Potential Call and Default. After the iteration is summarized, control of the experiment returns to the macro flow chart.

The next step in the macro flow chart causes the micro flow chart steps to be repeated for five hundred iterations. This generates a set of data for each mortgage design consisting of five hundred observations of the Potential Losses and internal rates of return. The output data is then used to calculate the proportions of occurrance of each of the Potential Losses. When this is done the program loops back to the micro flow chart and repeats it another five hundred times. This generates a second set of data that is used to calculate the size of the Potential Losses when incurred.

The next step of the flow chart is to change the design of the mortgage being examined and repeat the process. This is done until the proportions and size of the Potential Losses for each mortgage design are calculated.

The proportions of the non-zero observations of each Potential Loss are compared using a proportions Z-statistic. This statistic determines whether the difference in the number of non-zero observations between two instruments is significant. The results of this procedure reveal the impact that the examined instrument designs have upon the triggering events. Instruments with a higher proportion of non-zero observations have a greater probability of meeting the necessary conditions that were defined as triggering events for that Potential Loss. This statistical test does not estimate the impact upon the lender caused by having a mortgage's condition meet the triggering events for a Potential Loss. It reveals which instruments are more likely to meet or exceed the triggering events of a Potential Loss.

The next set of tests compare the sizes of the Potential Losses

that are incurred. This done by using the Mann-Whitney non-parametic runs test. This test is chosen because there is no evidence or theory that suggests what the distribution of the Potential Losses should be and this test requires no distributional conditions. The Mann-Whitney statistic reveals whether the difference in the size of the Potential Losses generated by one instrument is significantly different from those of another instrument. The results of this test reveal the impact that a Potential Loss condition may have upon a lender. Larger Potential Losses imply larger losses for the lender.

The two statistical tests are applied to two different sets of data generated by the same simulation program. The results of the statistical tests reveal which instruments are more likely to incur a particular Potential Loss and which instruments generate the largest Potential Losses for a lender. The significance level for all tests is set at 0.01 which implies a Z value of 2.33.

The final step in the macro flowchart is to alter the disturbance terms. The upward biased set is replaced with the neutral set and teh process is started anew. There are four sets of data generated for each of the thirteen mortgage designs examined.

Table 5.1

The Mortgage Parameters

Initial House Value *	$71,900.00
Initial Loan to Value Ratio	90.0%
Initial Income Level *	$2070.00 per month
Initial Contract Rate	12%
Closing Costs	2% of Balance
Prepayment Penalty	
Fixed Rate Mortgage	3% of Balance
Adjustable Rate Mortgage	0% of Balance
Initial Term to Maturity	360 Months
Expected Termination Date **	144 Months

* Average Level in December of 1983.

** Assumed termination date of deliverable grade CDR GNMA for futures contracts.[84]

[84] Chicago Board of Trade. An Introduction to Financial Futures. pp. 26.

Table 5.2

Disturbance Terms

	A/Lag(A)				
	Mean	Standard Deviation	K-S Normal Z	Actual Series High	Low
* Interest Rates					
BAA Corp. Bonds	1.004	0.017	1.548	16.37	7.42
Five Yr. T-Note	1.006	0.048	0.630	15.93	5.00
Three Yr. T-Note	1.006	0.057	0.682	16.21	4.50
One Yr. T-Note	1.007	0.075	0.696	16.71	3.69

	A-Lag(A)		Probabilities of Same Direction Change	
	Minimum	Maximum	Negative Change	Positive Change
BAA Corporate Bonds	-0.87	0.7	0.640	0.729
Five Year T-Note	-1.89	1.86	0.509	0.626
Three Year T-Note	-2.58	1.96	0.527	0.640
One Year T-Note	-3.91	1.90	0.490	0.608

	A/Lag(A)		
	Mean	Standard Deviation	K-S Normal Z
House Values	1.0073	0.0144	0.462

	Ln(A)/LN(Lag(A))		
	Mean	Standard Deviation	K-S Normal Z
Monthly Income	1.0006	0.0002	1.655

*
Data collected from Fedreal Reserve Bulletins from January 1971 to December 1983.

Table 5.3

Macro Flow Chart

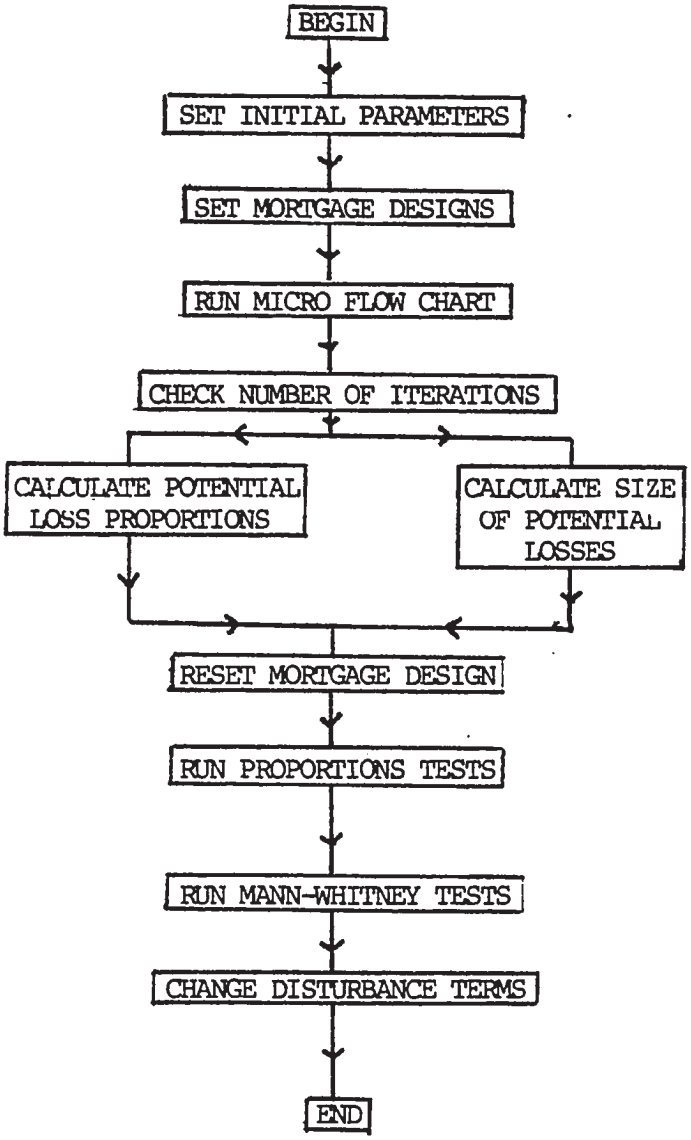
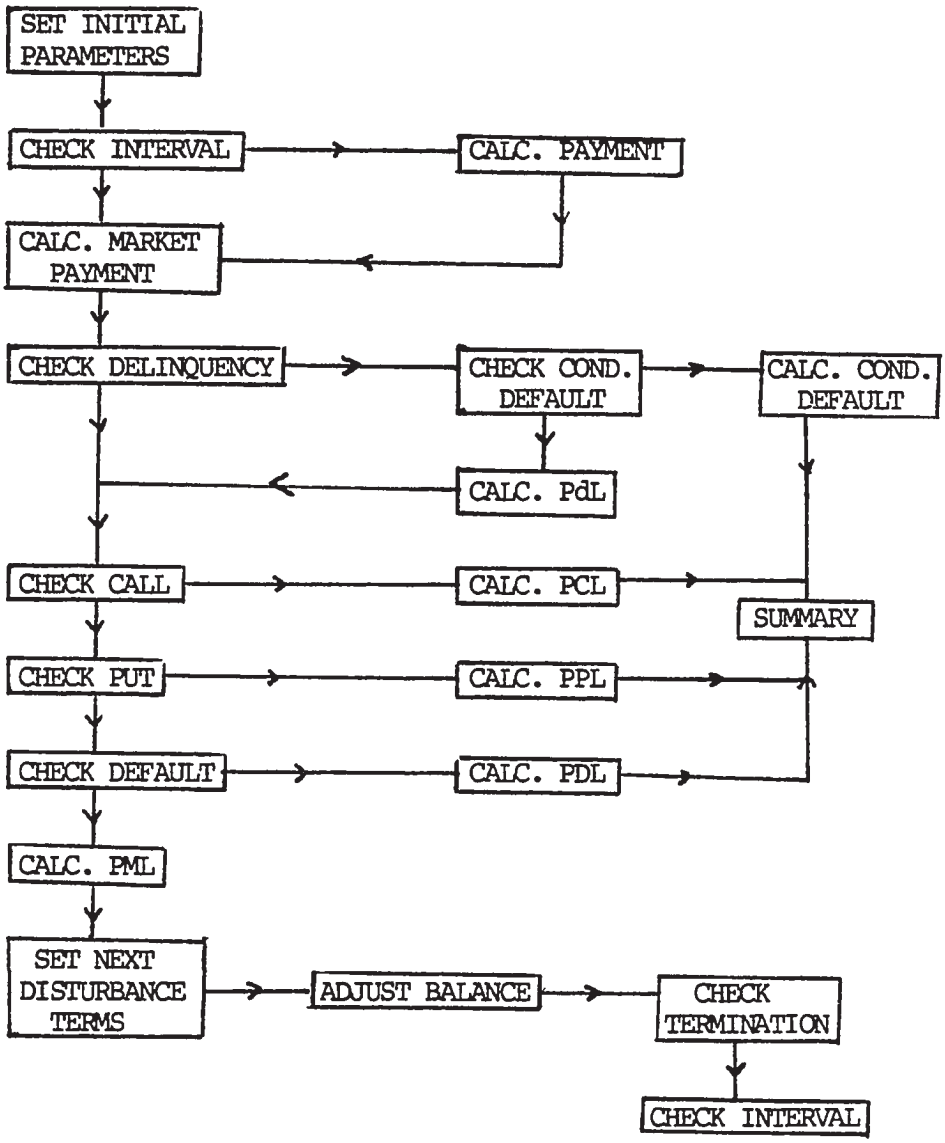


Table 5.4

Micro Flow Chart



CHAPTER VI

RESULTS FROM THE BASIC MORTGAGE DESIGNS

The impact of the adjustment mechanisms and intervals on the risk exposure of different mortgage designs is explored using the Monte Carlo experiment described in the previous chapter. The results discussed in this chapter are developed using the upward biased disturbance term set. The results reveal the relationships between mortgage risks and basic mortgage design provisions. Understanding these relationships is the primary factor in pricing (setting the initial contract rate) alternative mortgage instruments.

The impact of adjustment mechanism and interval upon mortgage risks are revealed by comparing the probability of incurring a Potential Loss and the size of the Potential Loss. This is done by generating Potential Loss data sets under assumed conditions for each of ten basic mortgage designs. The ten designs include the fixed rate, adjustable payment, term, and balance mortgages. Each of the adjustable mortgages is simulated with a one, three and five year adjustment interval. The design of these instruments allows the impact of individual mortgage provisions to be isolated and measured in the comparison process. The stochastic process of the simulation disturbance terms, interest rates, income levels, and house values, are governed by the data described in Chapter Five and presented in Table 5.2. It should be noted that the stochastic process of each disturbance term has an upward bias. This implies rising interest rates, income levels, and house values.

The comparison of the probability and size of the Potential Losses is achieved using two statistical tests. The first is the proportions Z statistic. This statistic reveals whether two proportions are significantly different. In this case the hypothesis is:

$$PLP_{nm} > PLP_{nk}$$

where PLP_{nm} is the proportion of occurrance of Potential Loss n for mortgage design m, and PLP_{nk} is the proportion of occurrance of Potential Loss n for mortgage design k. The second test is the Mann-Whitney non-parametric significance test. This test compares the size of the non-zero Potential Loss values. The hypothesis being tested is:

$$PL_{nm} > PL_{nk}$$

where PL_{nm} is the size of Potential Loss n of mortgage design m, and PL_{nk} is the size of Potential Loss n of mortgage design k. The significance level for both tests is set at alpha equals 0.01 which implies that the Z statistic must be greater than 2.33 for the hypothesis to be true.

The Proportions Results

The proportions calculations are applied only to those Potential Losses that are incurred. Put, Call, Delinquency and Conditional Default Gain have positive proportions. The other Potential Losses are not incurred during the simulations of the ten basic mortgage designs using

upward biased stochastic processes for the disturbance terms. The proportions of the Potential Losses are presented in Table 6.1. Table 6.2 presents the results of the proportions comparison tests. Only those comparisons that have meaningful results are presented.

Table 6.1 reveals that only Potential Put, Call, and Delinquency Losses and Conditional Default Gains have positive proportions. In the table a value of 1.0 means that the instrument incurred that Potential Loss in all iterations. A value of 0.75 means that the Potential Loss was incurred in seventy-five percent of the iterations. The causes, proportions and comparison results of each Potential Loss are discussed independently. It should be noted that the proportions of some of the Potential Losses are dependent on each other and others are mutually exclusive. Conditional Defaults cannot be incurred without Potential Delinquency. Potential Call and Put Losses cannot be incurred on the same iteration of a mortgage.

Causes of Potential Losses

The triggering event of Potential Call Losses is based upon a rational refinancing decision by the borrower. The benefits of refinancing must exceed the costs of refinancing for a Potential Call Loss to be incurred. The benefits consist of the present value of the difference between the current mortgage payment and that of an identical mortgage with the current market required contract rate from the point of refinancing unitl the expected termination date or the end of the current adjustment interval, whichever comes first, plus the present

Table 6.1

Basic Mortgage Design Potential Loss Proportions

	Potential Loss			
Instrument	PPL	PCL	PdL	CDG
Fixed Rate	0.154	0.75	0.0	0.0
Adjustable Payment				
One Year Adj.	0.0	0.844	0.30	0.156
Three Year Adj.	0.0.	1.0	0.026	0.0
Five Year Adj.	0.0	1.0	0.0	0.0
Adjustable Balance				
One Year Adj.	0.0	1.0	0.0	0.0
Three Year Adj.	0.0	1.0	0.0	0.0
Five Year Adj.	0.0	1.0	0.0	0.0
Adjustable Term				
One Year Adj.	0.0	1.0	0.0	0.0
Three Year Adj.	0.0	1.0	0.0	0.0
Five Year Adj.	0.0	1.0	0.0	0.0

PPL = Potential Put Loss
PCL = Potential Call Loss
PdL = Potential Delinquency Loss
CDG = Conditional Default Gain

Table 6.2

Basic Mortgage Design Potential Loss Proportions Z Statistics

Potential Put Loss

	All Other Basic Mortgage Designs
Fixed Rate Mortgage	9.133*

Potential Call Loss

	Adjustable Payment One Year Adj.	All Other Designs
Fixed Rate Mortgage	3.695*	11.952*
Adjustable Payment One Year Adj.	n.a.	9.197*

Potential Delinquency Loss

	Adjustable Payment Three Year Adj.	All Other Designs
Adjustable Payment One Year Adj.	11.729*	13.284*
Three Year Adj.		2.609*

Conditional Default Gains

	All Other Basic Mortgage Designs
Adjustable Payment One Year Adj.	9.197*

* Significant at the 0.01 level.

value of the difference in the mortgage balances at the expected termination date or end of the current adjustment period. The costs of refinancing consist of the prepayment penalty and the closing cost on the new mortgage. Different mortgage designs influence the costs and benefits of refinancing in several ways. The impact of mortgage designs on the cost of refinancing is limited to the size of the prepayment penalty. Fixed rate mortgages carry a three percent prepayment penalty and adjustable rate mortgages carry no prepayment penalty. This implies that fixed rate mortgages should have a lower proportion of Potential Call Losses than adjustable rate mortgages.

The length of the adjustment interval is highly correlated to the length of time over which the benefits from refinancing accrue. The longer this interval the greater the impact of a given spread between the current contract rate and the market required contract rate. As the period over which refinancing benefits accrue increases the size of the refinancing benefits increase. Larger refinancing benefits provide more incentive for a rational borrower to call the mortgage and refinance. Therefore, longer adjustment intervals should equate to a higher proportion of otential Call Losses. The total impact of mortgage design upon Potential Call Losses is a function of the length of time over which the borrower's benefits from refinancing accrue and the presence of a prepayment penalty. of time over which benefits accrue and the prepayment penalty.

Potential Put Losses can only be incurred if the mortgage survives beyond its expected termination date. This implies that the condition of the mortgage does not reach a level that would cause a terminal

Potential Loss to be triggered. Further, once the life of the mortgage reaches the expected termination date the market required contract rate must be lower than that of the current mortgage but not low enouch to trigger a Potential Call Loss. Potential Put Losses are encouraged by stable contract and market contract rates, rising income and rising house values. If house values and income levels are increasing the probability of incurring a default related terminal loss declines. If the market and mortgage contract rates are stable, the probability of incurring a Potential Call Loss are less. Avoiding other terminal Potential Losses is the key to incurring Potential Put Losses.

Potential Delinquency Losses are caused by an increase in the payment to income ratio to thirty-four percent or higher. There are only two factors that can change the payment to income ratio: the monthly payment and the level of income. For all mortgage designs the level of monthly income is simulated using the same stochastic process. This implies that any differences in the level of Potential Delinquency Losses must be attributed to differences in the monthly payment caused by differences in the mortgage design. The only mortgage instruments that have an adjustable payment feature are the adjustable rate mortgages. Among these only the adjustable payment mortgage has a scheduled pattern of payment changes. The adjustable balance and term mortgages do not change the monthly payment unless the conditions for the mandatory payment adjustment are met.

The adjustable payment mortgage should have the highest proportion of Potential Delinquency Losses. Shorter adjustment intervals should

also generate higher proportions of Potential Delinquency Losses because they have more opportunities to change the monthly payment. Assume all mortgages last ten years without premature termination for any reason. The mortgage design that alters the monthly payment every twelve months has nine opportunities to increase the monthly payment. A three year adjustable payment mortgage has three opportunities to increase the monthly payment and a five year adjustable payment mortgage has only one opportunity to increase the monthly payment. It should be obvious that the shorter adjustment intervals provide greater opportunities for payment increases. Greater opportunities for payment increases provide greater opportunites for the payment to income ratio to increase resulting in delinquency. Shorter adjustment intervals and the adjustable payment mechanism should result in the highest proportion of Potential Delinquency Losses.

Conditional Default Losses are influenced by the same factors that influence delinquency. Shorter adjustment intervals and the adjustable payment mechanism should generate larger proportions of Conditional Defaults.

Potential Call Loss Results

The proportions comparison test results, presented in Table 6.2 reveal that the fixed rate and adjustable payment mortgage with a one year adjustment interval have a significantly lower Potential Call Loss proportion than the other eight mortgage designs. The two mortgage designs have lower proportions for very different reasons. The one year

adjustable payment mortgage has a low proportion of Potential Call Losses due to its relatively high exposure to Conditional Default. The terminal Potential Losses are mutually exclusive. Therefore, if a mortgage design is terminated by a Conditional Default, it cannot be terminated by a Potential Call Loss. The results indicate that the proportion of Potential Call Losses of the one year adjustable payment mortgage are significantly lower than those of the one year adjustable term and balance. This result, while significant, is not considered to be an indication of a resistance to Potential Call Losses inherent in the adjustable payment mechanism or one year adjustment interval.

The significantly lower proportion Potential Call Losses associated with fixed rate mortgages can be attributed to an inherent resistance to mortgage calls caused by the presence of a positive prepayment penalty. The impact of the prepayment penalty is to increase the costs associated with the refinancing decision. Anything that increases the cost of refinancing reduces the borrower's incentive to refinance by lowering the ultimate refinancing benefit. The results indicate that a three percent prepayment penalty significantly reduces the proportion of Potential Call Losses.

The relatively high proportion of Potential Call Losses associated with the remaining eight mortgage designs can be attributed to the interplay of the volatility of the related index and the length of time over which refinancing benefits can accrue. Notice that all of the remaining designs are adjustable rate mortgages and cannot have a prepayment penalty. The results indicate that the volatility of the indices related to the adjustable rate mortgages dominate the shorter

adjustment intervals over which borrower refinancing benefits accrue. The high proportion of Potential Call Losses for the one year adjustment interval designs is explained in detail. The rationalization presented is easily generalized to explain the three and five year results. The key to Potential Call Losses lies in the volatility of the related index. Assume a one year interval adjustable payment mortgage with a $60,000 remaining balance is being examined for possible refinancing. The closing costs on the replacement mortgage are $1,200 (2% of the balance). The contract rate on the mortgage is 12% and the replacement mortgage has a contract rate of 9%.[67] The monthly payment on the mortgage is $619.41 based on the original life of three hundred and sixty months. The replacement mortgage has a monthly payment of $486.23 based on a life of three hundred and forty seven months and a nine percent contract rate. The contract rate of the current mortgage changes in eleven months. The present value of the difference in the payments over the eleven month benefit accrual period using a nine percent annual discount rate is $1,401.12. Without considering the difference in the remaining balances of the two mortgages at the end of the eleven month benefit accrual period, the benefits associated with the refinancing operation exceed the costs. The impact of wide fluctuations in the index rate encourage Potential Call Losses to a greater extent than the the

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[67] The maximum decline in the one year interest rate index is 3.91%. This is over three standard deviations from the mean but mortgages calls do not have to be the result of the change in the index rate for only one month.See Table 5.2.

reduction in the refinancing benefit accrual period hinders Potential Call Losses. These results indicate that the inclusion of a prepayment penalty in the design of adjustable rate mortgages would reduce the need to charge an additional premia in the mortgage contract rate for early termination risk.

Potential Put Losses

The Potential Put Loss is only incurred by the fixed rate mortgage. This is a function of the fixed rate mortgage's ability to evade other forms of termination. The fixed rate mortgage has a lower proportion of Potential Call Losses than any of the other instruments and does not incur any type of default loss. This can be attributed to its stable payment and amortization patterns, prepayment penalty, and smaller monthly changes in its related index.

Potential Delinquency Losses

The factors that influence the proportion of Potential Delinquency Losses are the monthly payments of a mortgage and the monthly income of a borrower. In the simulation model, the income series is governed by a stochastic process that has an upward bias. As income rises the probability of meeting the triggering conditions for Potential Delinquency Losses declines. All instruments are simulated using the same stochastic process to govern the income pattern. This implies that any significant differences in the proportion of Potential Delinquency

Losses is the result of the impact of the mortgage design on the monthly payment. The fixed rate mortgage does not alter the monthly payment and incurs no Potential Delinquency Losses. The adjustable term and balance mortgages do not alter the monthly payment unless the necessary conditions for the five year mandatory payment change are met. To invoke the mandatory payment change the remaining balance at the end of any five year period from the origination date must be to large to be fully amortized by the mortgage termination date at the contract rate in effect at that time. If this occurs the payment is increased to allow full amortization of the remaining balance by the termination date. None of the adjustable term or balance loans incur Potential Delinquency Losses. This implies that the mandatory payment adjustment is not invoked or if it is, the payment change is not large enough to trigger delinquency. Two of the three adjustable payment mortgages incur Potential delinquency Losses. The five year adjustable payment mortgage does not incur delinquency losses. The five year adjustable payment mortgage allows borrower income to change over sixty months. Since there is an upward bias in the income series, and there are no Potential Delinquency Losses associated with the five year interval mortgage, it can be inferred that any increase in the monthly payment after a five year period is not large enough to offset the growth in the monthly income that occurs over the five year period.

The proportion of Potential Delinquency Losses of the one and three year adjustable payment mortgages are significantly different from zero and from each other. The size of the monthly changes in the related index rate and the frequency of changes in the contract rate reflected

by changes in the monthly payment cause these two instruments to incur Potential Delinquency Losses. The one year interval mortgage incurs a significantly higher proportion of Potential Delinquency Losses than the three year. This can be explained by the difference in the size of the allowable monthly changes in the related indices and the shorter period between payment changes. Shorter time periods reduce the expected growth in the borrower's income. This implies that a smaller payment increase can trigger delinquency and that delinquencies that do occur are more likely to persist than those of the three year adjustable payment mortgage. This is confirmed by the Conditional Default results. The one year adjustable payment mortgage is the only instrument to incur a proportion of Conditional Defaults that is significantly different from zero. All of these Conditional Defaults are Gains reflecting the upward bias in housing values. The causes of Conditional Default are identical to those of Potential Delinquency Losses. Conditional Defaults are the result of delinquency that lasts for more than three months. The Potential Delinquency and Conditional Default results indicate that allowing payments to change without limitations as often as every twelve months causes a significant increase in the exposure of the lender to delinquency and delinquency related default losses.

The Mann-Whitney Test Results

The Mann-Whitney significance test is used to determine how the various mortgage provisions impact the size of Potential Losses once

they are incurred. The test is only performed for those Potential Losses that have positive Potential Loss proportions for more than one instrument. All other combinations would yield meaningless results. Under the ten basic mortgage designs the Mann-Whitney test is applied to Potential Call, Delinquency, and Market Losses. It is also used to compare the internal rates of return of the various mortgage designs. Table 6.3 presents the Potential Loss data, internal rate of return and termination month by instrument. Tables 6.4 to 6.7 present the results of the Mann-Whitney significance tests. The results are discussed by Potential Loss category.

Determinants of Potential Loss Size

The determinaints of Potential Loss size consist of contract provisions that are instrument specific and the stochastic processes governing the disturbance terms. The instrument specific provisions include the adjustment mechanism, and interval and prepayment penalty. The other factors influencing the size of a Potential Loss are the related interest rate index, house values and income. Some of the determinants are Potential Loss specific and some impact all Potential Losses.

Table 6.3

Parameters of Non-Zero Potential Loss Data by Instrument

Initial Mortgage Balance $64,710.00

Fixed Rate Mortgage

	Mean	Standard Deviation	Low	High
Potential Put Loss	$670.116	517.299	80.31	1277.17
Potential Call Loss	$2908.066	2322.504	358.13	8665.99
Pot. Market Loss	21.779%	16.331	4.17	44.40
Termination Month	63.87	74.33	7.0	304.00
Rate of Return	13.249%	1.179	12.0	14.87

Table 6.3 cont.

Adjustable Payment Mortgages

One Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$1523.759	371.278	547.07	2098.50
Pot. Delinq. Loss	$1852.856	386.53	1032.31	2496.15
Cond. Default Gain	$10180.560	4993.37	2499.44	18308.30
Pot. Market Loss	0.915%	0.629	0.26	3.79
Termination Month	20.328	20.937	7.00	134.00
Rate of Return	10.116%	1.06	6.62	11.87

Three Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$3311.043	2408.23	792.02	10324.45
Pot. Delinq. Loss	$1520.19	328.22	1050.09	1786.32
Pot. Market Loss	2.910%	1.689	0.970	8.08
Termination Month	13.89	9.93	7.00	49.00
Rate of Return	10.964%	0.433	10.54	12.36

Table 6.3 cont.

Adjustable Payment Mortgage

Five Year Adjustment Period

	Mean	Standard Deviation	Low	High
Potential Call Loss	$4467.215	4024.119	696.56	16424.17
Pot. Market Loss	5.17%	3.62	1.73	16.55
Termination Month	15.06	12.66	7.00	74.00
Rate of Return	10.991%	0.467	10.54	74.00

Table 6.3 cont.

Adjustable Balance Mortgage

One Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$1417.20	394.662	429.87	2105.08
Pot. Market Loss	1.11%	0.919	0.250	5.24
Termination Month	21.58	18.15	7.00	100.00
Rate of Return	10.69%	1.186	6.79	12.83

Three Year Adjustment Interval

	Mean	Standard Dev'at'on	Low	High
otential Call Loss	$3373.33	2453.80	778.11	10324.45
Pot. Market Loss	2.91%	1.70	0.97	7.81
Termination Month	13.99	10.16	7.00	49.00
Rate of Return	10.97%	0.464	10.54	12.36

Five Year Adjustment Interval

	Mean	Standard ev at'on	Low	High
Potential Call Loss	$4499.29	4000.28	713.31	16424.17
Pot. Market Loss	5.12%	3.514	1.73	16.14
Termination Month	14.79	12.13	7.00	74.00
Rate of Return	10.99%	0.459	10.54	12.20

Table 6.3 cont.

Adjustable Term Mortgage

One Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$1418.82	394.80	429.89	2105.08
Pot. Market Loss	1.10%	0.91	0.25	5.24
Termination Month	21.40	17.99	7.00	100.00
Rate of Return	10.65%	1.15	7.32	12.83

Three Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$3347.10	2451.22	778.05	10324.45
Pot. Market Loss	2.925%	1.69	0.97	7.81
Termination Month	13.98	10.03	7.00	49.00
Rate of Return	10.98%	0.456	10.54	12.36

Five Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$4551.06	4045.27	705.23	16424.17
Pot. Market Loss	5.12%	3.602	1.73	16.14
Termination Month	14.92	12.59	7.00	74.00
Rate of Return	10.98%	0.467	10.54	12.20

The most important relationship in determining the size of any of the Potential Losses is the pattern of change of the associated interest rate index. If all other provisions of a mortgage are held constant and only the volatility of the related index is allowed to increase, the size of the Potential Losses increases. Higher volatility in the related interest rate index implies larger differences between the contract rate and the market required rate for the mortgage and between the old and new contract rate at any adjustment point. The larger differences in the rates creates larger changes in the adjustment mechanism, or larger differences between the value of the current mortgage and a market mortgage. Large increases in the contract rate cause either large increases in the monthly payment or decreases in the amount of the monthly payment applied to principal. Increases in the monthly payment imply increased delinquency risk and a slowdown in the amortization of the balance implies increased default risk. Decreases in the market required rate causes increses in the benefit recieved by borrowers through refinancing. If the contract rate of the mortgage falls all parties to the mortgage benefit. In general rapid declines or increases in the related index cause an increase in mortgage risk. Table 5.2 presents the parameters of the stochastic processes used to simulate the related indices. The parameters indicate that the speed of an increase or decrease in the index increases as the length of the maturity of the index fall. In other words the one year index can move from eight to ten percent in less time than the three or five year or fixed rate indices can. The shorter the length of the maturity of the related index the greater the exposure to mortgage risks.

Default losses are proportional to the loan to value ratio at the end of each month of the mortgage's life. If the loan to value ratio rises, the size of default losses increases. If this ratio falls, the size of default losses declines. The size of the loan to value ratio is influenced by the market value of the house and the amortization pattern of the mortgage. If the house value increases, the size of default losses declines. If house values decline, default losses increase. If the amortization pattern is constant and the remaining balance of the loan declines in each month, the size of default losses decline. If the rate of decline in the remaining balnce increases, default losses decline and if the rate decreases default losses increase. The adjustable term and balance loans are the only designs that alter the amortization rate.

Delinquency risk is influenced by the payment to income ratio. If the payment to income ratio increases, the probability of incurring delinquency losses increases. The size of Potential Delinquency Losses is a function of the size of the monthly payment. If the monthly payment increases, the size of Potential Delinquency Losses increase. If the payments are unstable and change frequently, the size of Potential Delinquency Losses increase. The Potential Delinquency Loss measure is accumulative. This implies that mortgage designs with unstable payment patterns have increased Potential Delinquency Losses. An instrument may suffer a one month delinquency in each of several years causing a higher Potential Delinquency Loss than an instrument that suffers four consecutive months of delinquency losses and lapses into default.

Conditional Default limits the size of Delinquency Losses in some cases.

The method used by the mortgage to respond to changes in the contract rate has an impact on the size of the Potential Loss. Potential Default Losses should be higher for adjustable term and balance mortgages because both alter the rate at which the balance declines. Delinquency losses should be higher for adjustable payment mortgages because they alter the payment stream and decrease the stability of the monthly payment. The more unstable the monthly payment the higher the Potential Delinquency Losses

The adjustment interval influences mortgage risks by altering the pattern of the contract rate of the mortgage. The less stable the contract rate the more often the condition of the mortgage changes. In some cases this implies lower losses while in others it implies higher losses. If the contract rate of the mortgage is higher than it was at origination, a longer adjustment interval implies a higher losses. If the contract rate is lower than it was at origination, a longer adjustment period implies lower losses. The bias of the interest rate series is upward. This implies higher Potential Losses for longer interval designs.

The final mortgage provision to impact Potential Loss size is the prepayment penalty. When the prepayment penalty is positive it reduces Potential Call Losses. The prepayment penalty is paid to the lender to compensate him for allowing the borrower to call the mortgage. Under a refinaincing operation, the borrower refinances with a lower contract rate mortgage. The lender reinvests the proceeds from the prepayment into other mortgages that have a lower contract rate. The prepayment

penalty is designed to reduce both the probability of rational mortgage calls and the lender's loss.

Potential Call Losses

The size of Potential Call Losses are positively related to the of the lender's loss accrual period. As the maximum length of lender loss accrual increases from eleven to thirty-five to fifty-nine months, the size of the Potential Call Losses increases significantly. There is one exception to this pattern. The fixed rate mortgage has a significantly higher Potential Call Loss than the one year adjustables but lower than the three and five year adjustables. This result is due to the presence of a prepayment penalty in the fixed rate mortgage design. This implies that a three percent prepayment penalty has a significant impact on the size of the Potential Call Losses.

The Potential Call Losses of the one year adjustable payment mortgage are significantly larger than those of the one year adjustable term and balance mortgages. This result can be explained by a series of events. At the twelve month adjustment point, the contract rate on the mortgages is increased. This causes the payment of the adjustable payment mortgage to increase. The payment of the adjustable term and balance mortgages remains the same. They recognize the change in the contract rate by altering the remaining balance amortization. Then, the market required rate of return falls. This creates a refinancing benefit for the borrower and a loss for the lender. The loss on the adjustable

Table 6.4

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Call Losses

Comparison By Adjustment Mechanism

One Year Adjustment Intervals

	Adjustable Payment	Adjustable Balance	Adjustable Term
Fixed	7.2087*	9.2498*	9.2376*
Var. Payment		4.5827*	4.5317*
Var. Balance			0.0367

Three Year Adjustment Intervals

	Adjustable Payment	Adjustable Balance	Adjustable Term
Fixed	4.4266*	4.655*	4.5229*
Var. Payment		0.2723	0.0369
Var. Balance			0.2340

Five Year Adjustment Intervals

	Adjustable Payment	Adjustable Balance	Adjustable Term
Fixed	6.6022*	7.0123*	7.0044*
Var. Payment		0.4137	0.4450
Var. Balance			0.0393

* Result is significant at the 0.01 level.

Table 6.4 cont.

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Call Losses

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Adjustment	Five Year Adjustment
	*	*
One Year Adjustment	15.5805	16.2723 *
Three Year Adjustment		3.1656

Adjustable Balance Instruments

	Three Year Adjustment	Five Year Adjustment
	*	*
One Year Adjustment	17.9969	19.2754 *
Three Year Adjustment		3.3773

Adjustable Term Instruments

	Three Year Adjustment	Five Year Adjustment
	*	*
One Year Adjsutment	17.8164	18.9897 *
Three Year Adjustment		3.6218

*
Result is significant at the 0.01 level.

payment mortgage is larger than that of the adjustable term and balance. This can be explained by the difference in the size and timing of refinancing benefit accrual. The refinancing benefit associated with the reduction in the monthly payments is larger for the adjustable payment mortgages due to the difference in the size of the monthly payments. The benefit associated with the difference in the size of the remaining balance is larger for the adjustable term and balance mortgages. The timing of the receipt of the benefits causes the impact of the difference in the payment streams of the adjustable payment mortgage to dominate the impact of the difference in the remaining balances of the adjustable term and balance mortgages. This generates significantly larger Potential Call Losses for the adjustable payment mortgage with a one year interval than for adjustable term or balance mortgages with a one year interval.

The Potential Call Losses of the three and five year adjustable mortgages are not significantly different across adjustment mechanisms. This is caused by the relationship between the average termination month of the these mortgages and their adjustment intervals. The average termination month of each of these instruments is less than the adjustment interval. This implies that when the Potential Call Loss benefits are calculated there are no differences in the lender's loss associated with payment benefits or remaining balance differences because none of the mortgages have, on average, altered their payment or amortization rate by the time they are called.

The results of the Potential Call Loss comparison indicate two items of importance. Mortgage designs with three and five year

adjustment intervals should carry prepayment penalties to reduce the size of their Potential Call Losses and the prepayment penalty should increase as the interval between adjustments to the contract rate increases. Using these two concepts in the design of mortgage instruments should allow lenders to reduce the size of the prepayment premia that is included in the contract rate of efficiently priced mortgage instruments.

Potential Delinquency Losses

The only instruments to incur Potential Delinquency Losses are the one and three year adjustable payment mortgages. A comparison of the size of their losses reveals that they are not significantly different. This can be explained by the limitation placed upon delinquency losses by Conditional Default. If a mortgage remains in delinquency for three months it enters Conditional Default. This stops the accumulation of Potential Delinquency Losses. It should be noted that the one year adjustable payment mortgage is the only instrument to incur Conditional Defaults. The losses associated with Conditional Default cannot be compared because two sets are necessary for comparison. The implication of the presence of Conditional Default in only the one year instrument indicates that the Potential Delinquency Losses of the one year design are more severe than those of the three year design.

Table 6.5

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Delinquency Losses

Adjustable Payment Instrument

	Three Year Adjustment Interval
One Year Adjustment Interval	2.1565

Potential Market Losses

Potential Market Losses measure the impact of various mortgage designs on residual interest rate or market risk. The measure is calculated by finding the present value of the discount points that a lender would have to pay in each month in order to sell the mortgage instrument in that month on the secondary market. The discount points forfeited in any month are a function of the difference between the current mortgage contract rate and the contract rate required in the secondary market and the length of time until the assumed or implied prepayment of the mortgage. The difference between the current and market contract rate is a function of the volatility of the related index. The more volatile the index the greater the difference between the market and current contract rate. Longer adjustment intervals also imply a larger difference between the current and market contract rate due to potential trends in the movement of the related index. The most important factor in calculating the Potential Market Loss is the

Table 6.6

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Market Losses

Comparison By Adjustment Mechanism

One Year Adjustment Interval

	Adjustable Payment	Adjustable Balance	Adjustable Term
	*	*	*
Fixed	27.3725	27.2020	27.202
		*	*
Var. Payment		2.9445	2.7184
Var. Balance			0.2173

Three Year Adjustment Interval

	Adjustable Payment	Adjustable Balance	Adjustable Term
	*	*	*
Fixed	23.82	23.71	23.74
Var. Payment		0.0699	0.977
Var. Balance			0.1606

Five Year Adjustment Interval

	Adjustable Payment	Adjustable Balance	Adjustable Term
	*	*	*
Fixed	18.838	18.704	18.909
Var. Payment		0.0368	0.032
Var. Balance			0.2671

*
Results are significant at the 0.01 level.

Table 6.6 cont.

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Market Losses

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Adjustment	Five Year Adjustment
	*	*
One Year Adjustment	22.9609	25.8527 *
Three Year Adjustment		11.804

Adjustable Balance Instruments

	Three Year Adjustment	Five Year Adjustment
	*	*
One Year Adjustment	20.2953	24.593 *
Three Year Adjustment		12.003

Adjustable Term Instruments

	Three Year Adjustment	Five Year Adjustment
	*	*
One Year Adjustment	20.471	24.6023 *
Three Year Adjustment		11.4578

*
Results are significant at the 0.01 level.

prepayment date. For fixed rate mortgages this is assumed to be one hundred and forety-four months after the mortgage is originated. For adjustable rate mortgages the prepayment is assumed to be the end of the current adjustment interval. This reflects the fact that value of adjustable rate mortgages returns to parity with the market at the end of each adjustment interval. Longer adjustment intervals imply larger Potential Market Losses.

The results indicate that the fixed rate mortgage has significantly higher Potential Market Losses than any of the adjustable rate mortgages. The results also indicate that as the adjustment interval increases from one to three to five years, the size of the Potential Market Losses increases significantly. These results are as expected. The only surprising result is found between the one year interval adjustable payment and adjustable term and balance. The one year adjustable payment mortgage has significantly higher Potential Market Losses than either the one year adjustable term or balance instrument.

This result can be explained by timing of the factors of a Potential Market Loss. The difference between the market required contract rate and that of the mortgage causes losses in two ways. The higher market rate implies higher monthly payments. The difference in the monthly payments represents a loss to the lender. The second form of lender loss is the difference in the remaining balance at the next adjustment point. The impact of discounting is not the same on the two loss factors. The payment factor has a higher present value due to the timing of the losses than the remaining balance losses. This causes the adjustable payment with a one year interval to have a higher Potential

Market Loss than adjustable term and balance instruments with one year intervals.

The difference in the Potential Market Losses between instruments with different adjustment mechanisms and adjustment intervals of three or five years is not significant. This implies that the difference in the one year interval is caused by a pattern of contract rate change that involves a decrease at the first adjustment period causing a decline in the monthly payment of the adjustable payment mortgage, followed by an increase in the index rate. This pattern causes a larger difference in the monthly payments between the current adjustable payment and one with a market required contract rate than the payment difference for either the adjustable term or balance. Combine this with the timing of the losses described above, and it is easy to see why only the one year adjustable payment mortgage has a higher Potential Market Loss then the one year adjustable term and balance designs. Notice that this result is consistent with the Potential Call Loss result but the cause is a movement in the opposite direction of the interest rates.

Internal Rate of Return

The final comparison is between the internal rates of return of the various mortgage designs. The internal rates of return are calculated using all Potential Loss data except Potential Market Losses. Therefore these returns present information that can only be relied upon if the mortgage design is to be held until termination. The primary factors influencing the internal rate of return are the monthly payments,

Table 6.7

Comparison of The Internal Rates of Return
Using Mann-Whitney Z-Statistic

Comparison By Adjustment Mechanism

One Year Adjustment Interval

	Adjustable Payment	Adjustable Balance	Adjustable Term
	*	*	*
Fixed	27.443	25.2802	25.3908
		*	*
Var. Payment		10.1301	10.1157
Var. Balance			0.1616

Three Year Adjustment Interval

	Adjustable Payment	Adjustable Balance	Adjustable Term
	*	*	*
Fixed	27.3693	27.3711	27.3264
Var. Payment		0.2613	0.5368
Var. Balance			0.2638

Five Year Adjustment Interval

	Adjustable Payment	Adjustable Balance	Adjustable Term
	*	*	*
Fixed	27.3904	27.4213	27.4004
Var. Payment		0.0203	0.2878
Var. Balance			0.2696

*
Results are significant at the 0.01 level.

Table 6.7 cont.

Comparison of The Internal Rates of Return
Using Mann-Whitney Z-Statistic

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Adjustment	Five Year Adjustment
	*	*
One Year Adjustment	15.7715	15.9871
Three Year Adjustment		0.9152

Adjustable Balance Instruments

	Three Year Adjustment	Five Year Adjustment
	*	*
One Year Adjustment	2.7198	3.1064
Three Year Adjustment		0.6421

Adjustable Term Instrument

	Three Year Adjustment	Five Year Adjustment
	*	*
One Year Adjustment	3.1952	3.1809
Three Year Adjustment		0.0966

*
Results are significant at the 0.01 level.

Potential Losses, and prepayment penalty -- in short all cashflows associated with holding a mortgage until termination.

The results of the internal rate of return comparisons indicate that the fixed rate mortgage has a significantly higher return than any of the adjustable mortgages. This can be explained by the prepayment penalty. Whenever a fixed rate mortgage is called the rate of return to the lender increases because the terminal cashflow is larger than the remaining balance. Seventy five percent of the fixed rate mortgages are terminated by Potential Call Losses. This increases the average internal rate of return for these mortgage instruments. The internal rate of return on adjustable rate mortgages receives no boost from mortgage calls because there is no prepayment penalty. The result is that the internal rate of return on fixed rate mortgages is higher than that of adjustable rate mortgages.

The intrepretation of this result must be extremely limited. It must be remembered that the return calculated did not consider the impact of Potential Market Losses, an area in which the fixed rate mortgage is vulnerable. Therefore, the internal rate of return results merely confirm that the prepayment penalty has a substantial impact on the performance of a mortgage instrument.

It should also be pointed out that the mean internal rate of return of the adjustable rate mortgages is lower than the initial contract rate. Under upwardly biased interest rates this appears to be a contradiction. In reality it is not. The interest rates are upwardly biased but they are also limited to a minimum and maximum value. The maximum values are approximately thirty three percent higher than the

initial contract rate and the minimum values are approximately sixty-two percent smaller than the initial contract rate. This implies that the average index rate is lower than the contract rate even though the percentage change series are upwardly biased. The fact that the downward change can be greater than the upward change causes the mean of the internal rate of return to be lower than the initial contract rate. If the initial contract rate had been set below the mean of the related indices the internal rates of return would have been higher than the initial contract rate for the adjustable rate mortgages. The rate of return on adjustable rate mortgages is influenced more by the long run mean of the related index than by the initial contract rate. The return on fixed rate mortgages is influenced more by the initial contract rate than by the long run mean of the related index. Lenders should be aware of the position of interest rates relative to their long ren averages when they design a mortgage instrument. Adjustable rate mortgages protect lenders from increase in interest rates, but they also reduce lenders' returns when interest rates fall. The bias created by selecting an initial contract rate above the mean of the interest rate series is is not a serious weakness of the model because the results are used for comparison purposes and all results face the same bias.

Conclusions

The Potential Loss comparison tests yield information about the impact of the ten basic mortgage designs on mortgage risks. The results must be interpreted with an understanding of the distributions of the

disturbance terms and the definitions of the Potential Losses in mind. The implications of the Potential Call Loss comparisons are that the three and five year adjustment interval adjustable rate mortgages should be designed with prepayment penalties to reduce their exposure to call losses. Potential Delinquency Losses and Conditional Default Gains indicate that a one year variable payment mortgage increases the payment burden on the borrower significantly. This implies that mortgage designs should avoid one year payment adjustments or limit the size of the payment change. The impact of a per period payment cap is explored in the next chapter. The Potential Market Loss comparison reveals that the fixed rate mortgage has the most market risk and that shorter adjustment intervals decrease market risk. The results from the comparison of the internal rates of return confirmed the importance of prepayment penalties in the design of mortgage instruments.

Chapter VII

The Impact Of A Per Period Payment Cap

One of the more popular provisions of an adjustable payment mortgage is the payment cap. Payment caps restrict the ability of the mortgage payment to increase. Assume that a mortgage has a current monthly payment of $500.00. The contract rate is adjusted to the market index and the new monthly payment implied by the new contract rate is $550.00. The mortgage contains a payment cap provision that limits the increase of the monthly payment in any one month to 7.5 percent of the previous month's payment. In this case the implied maximum increase in the monthly payment is $37.50. This creates a shortage between the monthly payment to be made by the borrower and that implied by the contract rate of 12.50%. This shortage is reflected in the monthly reduction of the remaining balance. The decline in the remaining balance slows and possibly reverses. The most popular payment cap limits the increase in the monthly payment to 7.5 percent of the previous month's payment.[69]

The impact of the seven and one-half percent payment caps upon the mortgage risks is explored in this chapter. The method of exploration is identical to that presented in Chapter V. The results are presented in

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[69] Lynn, Delores. "Lender Experience With ARMs: A Summary of Case Study Findings." What Makes An ARM Sucessful?. Freddie Mac Publication No. 53C. pp.27.

the same manner that they are presented in Chapter VI.

The adjustable payment mortgage with a payment cap is essentially a hybrid between the adjustable payment and adjustable balance instruments. The primary attractiveness of the adjustable payment mortgage is that it provides increased cashflow to the lender when interest rates rise. Adjustable balance mortgages do not increase cashflow when interest rates rise due to their adjustment mechanism. This is of concern to lenders due to the manner in which income from adjustable rate mortgages is recognized and taxed. The Internal Revenue Service has ruled that interest payments are taxable in the year in which they become fixed, even if thay are not paid in that year.[70] The impact of this ruling is best explained by example. Assume an adjustable balance mortgage with a twelve month adjustment interval was issued twelve months ago with a contract rate of 10%. The initial balance is $100,000 with a term of thirty years, implying a monthly payment of $878.00. The contract rate is adjusted to twelve percent reflecting an increase in the related index. The implied monthly payment is $1,026.26. The interest earned each month by the lender, but not received is $116.44. This amounts to $1397.28 over the course of a year. This amount is taxable in the year even though it is not received. This creates a cashflow problem for the lender. He must pay real dollars in taxes on income that he does not receive until some later date. The exact size of the cashflow problem is a function of the lenders ability

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70Revenue Ruling 77-135 (IR 1795) 1977-1 C B 133.

to manipulate loan loss reserves and his tax bracket. Adjustable payment mortgages avoid the cashflow problem because interest income is received as it is recognized for tax purposes. The impact of tax regulations upon the cashflow of mortgage holders alters the relative attractiveness of the different mortgage designs. Further discussion of the impact of tax regulations on adjustable rate mortgages is left for future research.

The attractiveness of the adjustable balance mortgage lies in the level of payment burden it creates over the life of the loan. Chapter VI disclosed the significant difference in the probability of incurring Potential Delinquency Losses between adjustable payment and adjustable balance mortgages. The adjustable payment mortgage with payment caps is designed to contain some of the benefits of both the adjustable payment and adjustable balance mortgages. The payment is allowed to increase reducing the potential cashflow problem associated with paying tax on interest not recieved and the probability of delinquency is reduced by the limit on the ability of the payment to increase. This Chapter investigates the impact of payment caps on the Potential Loss measures.

The comparisons to be made using the proportions Z statistic and the Mann-Whitney significance test are limited to three sets. The first set compares the Potential Losses of the adjustable payment mortgage with a 7.5 percent payment cap to the Potential Losses of the fixed and adjustable rate mortgages with the same adjustment interval. The second set compares the Potential Losses of the adjustable payment mortgages with payment caps across adjustment interval. The third set compares the Potential Losses of the capped adjustable payment mortgages to the uncapped adjustable payment mortgages with longer adjustment intervals.

These three comparisons provide the information needed to estimate the impact of payment caps on mortgage risks.The Potential Loss data and comparison statistics are presented in Tables 7.1 to 7.5.

The Proportions Results

The proportions calculations are applied only to those Potential Losses that have a triggering event and incur the Potential Loss by at least one instrument. Table 7.1 reveals that only Potential Call and Delinquency Losses are incurred by adjustable payment mortgages with payment caps. Table 7.2 presents the results of the proportions test between the relevant designs and Potential Losses.

Potential Put Losses are not incurred by the capped adjustable payment designs. This is consistent with the results in Chapter VI and the explanation remains the same. The Potential Call Loss is incurred by all of the capped adjustable payment mortgages. This reflects the relationship between the volatility of the related index, length of the accrual of the borrower's call benefit and the presence or absence of a prepayment penalty. The one year capped adjustable payment mortgage is the only capped instrument to incur a Potential Delinquency Loss.

The comparison of the proportion of Potential Call Losses between the capped one year adjustable payment mortgage and the one year adjustable payment mortgage without a payment cap reveals a significant difference. The uncapped instrument has a lower proportion of Potential Call Losses than the capped design. This result can be explained by looking at the other terminal Potential Losses. In this case the

Table 7.1

Potential Loss Proportions For Adjustable Payment Mortgages with 7.5 % Per Period Payment Increase Limit

	Potential Loss			
Adj. Interval	PPL	PCL	PdL	CDG
One Year	0.0	1.0	0.012	0.0
Three Year	0.0	1.0	0.0	0.0
Five Year	0.0	1.0	0.0	0.0

PPL = Potential Put Loss
PCL = Potential Call Loss
PdL = Potential Delinquency Loss
CDG = Conditional Default Gain

Table 7.2

Potential Loss Proportions Z Statistics Between Basic Mortgage Designs and Adjustable Payment with 7.5% Payment Increase Limit per Adjustment Interval

Potential Put Loss

	Adjustable Payment with 7.5% Cap
Fixed Rate Mortgage	9.133*

Potential Call Loss

	Fixed Rate	Adj. Pay One Year Adj.
All Adj. Pay with Pay Cap	11.952*	9.197*

Potential Delinquency Loss

	Adj. Pay One Year	Adj. Pay Three Year	All Other Designs
Adj. Pay Cap One Year Adj.	12.55*	1.62	2.451*
Adj. Pay Cap Three Year Adj.	13.28*	3.62*	0.0
Adj. Pay Cap Five Year Adj.	13.28*	3.62*	0.0

Conditional Default Gains

	Adjustable Payment One Year
Adj. Pay Cap All Intervals	9.19*

* Results are significant at the 0.01 level.

uncapped design has a significantly higher proportion of Potential Default Gains. Any mortgage that incurs a terminal Potential Loss cannot incur a different terminal Potential Loss. The uncapped one year adjustable payment mortgage terminates 15.6 percent of the time by Conditional Default. The rest of the time it terminates by Potential Call Losses. This implies that without Conditional Default there would be no difference between the proportion of Potential Call Losses of the capped and uncapped one year adjustable payment mortgages. This conclusion is consistent with the results and discussion of Potential Call Losses presented in Chapter VI.

The Potential Losses of most interest in measuring the impact of payment caps are those related to delinquency. The proportion of Potential Delinquency Losses incurred by the one year adjustable payment mortgage with the payment cap is significantly lower than the proportion of Potential Delinquency Losses incurred by the uncapped one year adjustable payment mortgage. This result can be explained by the impact of restricting the increases in the monthly payment to 7.5%. Potential Delinquency Losses are caused by increases in the payment to income ratio to 34%. If the size of the payment increase is restricted the probability of a ratio with the payment in the numerator increasing has to decline. The results indicate that the payment cap of 7.5% significantly reduces the probability of the payment to income ratio reaching the critical level.

The proportion of Potential Delinquency Losses for the capped one year adjustable payment mortgage and the uncapped three year adjustable

payment mortgages are not significantly different. This implies that a 7.5% payment cap has the same impact on Potential Delinquency Losses as increasing the adjustment interval from one to three years and reducing the index volatility by changing from the one to three year index.

The one year capped adjustable payment design has a significantly higher proportion of Potential Delinquency Losses than any of the remaining mortgage designs. This is to be expected since none of the mortgage designs with a fixed payment for five or more years incurrs a Potential Delinquency Loss. The three and five year interval adjustable payment instruments with payment caps have a proportion of Potential Delinquency Losses of zero, significantly less than the one year adjustable payment capped and uncapped, and the three year uncapped. These results indicate that the 7.5% payment cap significantly reduces the proportion of Potential Delinquency Losses. It should also be noted that the propotion of Conditional Default Losses is reduced to zero by the payment cap. The results of the proportion test suggest that the 7.5 percent payment cap reduces delinquency risk significantly for the one and three year adjustable payment mortgages.

The Mann-Whitney Tests

The Mann-Whitney tests are used to measure the impact the payment cap has upon the relative size of the Potential Losses. There are three Potential Losses that are of interest to the payment cap provision; Potential Call Losses, Potential Delinquency Losses, and Potential Market Losses. The relevant comparisons of these Potential Losses across

Table 7.3

Parameters of Non-Zero Potential Loss Data by Instrument

One Year Adjustable Payment with 7.5% per Period Payment Cap

	Mean	Standard Deviation	Low	High
Potential Call Loss	$1463.58	384.40	632.17	2105.08
Pot. Delinquency Loss	$569.96	0.0	569.96	569.96
Pot. Market Loss	0.94%	0.604	0.250	3.22
Termination Month	21.55	18.34	7.0	100.0
Rate of Return	10.67%	1.18	7.16	12.82

Three Year Adjustable Payment with 7.5% per Period Payment Cap

	Mean	Standard Deviation	Low	High
Potential Call Loss	$3378.89	2468.44	791.98	10324.45
Pot. Market Loss	2.90%	1.67	0.97	7.95
Termination Month	13.938	10.06	7.0	49.0
Rate of Return	10.97%	0.462	10.54	12.36

Table 7.3 cont.

Parameters of Non-Zero Potential Loss Data by Instrument

Five Year Adjustable Payment with 7.5% per Period Payment Cap

	Mean	Standard Deviation	Low	High
Potential Call Loss	$4438.59	4009.65	696.45	16424.17
Pot. Market Loss	5.15%	3.57	1.73	16.34
Termination Month	14.98	12.47	7.0	74.0
Rate of Return	10.991%	0.46	10.54	12.20

various instruments are explained along with the internal rate of return comparison. The results are then summarized into conclusions about alternative mortgage design.

Potential Call Losses

The Mann-Whitney comparison of Potential Call Losses reveals several interesting points about the behavior of adjustable payment mortgages with 7.5 percent payment change caps. In all but one case the Potential Call Losses of the adjustable rate mortgage with the payment cap are not significantly different from those of the other adjustable rate mortgages with the same adjustment interval. The exception is the one year uncapped adjustable payment mortgage. This instrument has a significantly higher Potential Call Loss than the one year adjustable payment with a payment cap. The explanation for this can be found in Chapter VI. It is pointed out in Chapter VI that the one year adjustable payment mortgage has significantly higher Potential Call Losses than the one year adjustable term or balance designs. The primary cause of this is the relative size and timing of the components of the Potential Call Losses. The explanation presented in Chapter VI eluded to a pattern of index rates that would cause the monthly payment to increase at one adjustment period. Then, prior to the next adjustment period the index rate would fall creating the incentive for a rational mortgage call. This pattern causes the difference between the old monthly payment and that of the market monthly payment to be much larger than for either the adjustable balance or term mortgages. Now, it is revealed that the payment difference for a one year uncapped adjustable

payment mortgage would be larger than for a one year capped adjustable payment mortgage. The size of that difference combined with discounting the remaining balance differences, creates the larger Potential Call Losses for the one year adjustable payment mortgage. The same impact is not found in three and five year designs. The payment cap evidence indicates that Potential Call Losses increase as the volatility of the monthly payment increases. The results indicate that the payment cap causes the behavior of the adjustable payment mortgage to mimic the behavior of the adjustable balance mortgage where Potential Call Losses are involved.

The Potential Call Losses of the adjustable payment mortgages with payment caps are also compared to those of the adjustable payment mortgages with longer intervals with and without payment caps. The results indicate the size of the Potential Call Loss increases significantly as the adjustment interval increases from one to three to five years. This relationship holds true with and without payment caps. In other words the presence of a 7.5 percent payment cap does not offset the increase in the Potential Call Loss due to a lengthened lender loss accrual period.

The impact of a 7.5 percent payment cap on the level of Potential Call Losses of adjustable payment mortgages is to cause the instrument to behave as if it were an adjustable term or balance mortgage with the same adjustment interval.

Table 7.4

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Call Losses

Comparison By Adjustment Mechanism

One Year Adjustment Intervals

	Fixed	Adj. Pay.	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	8.75*	3.47*	1.47	1.44

Three Year Adjustment Intervals

	Fixed	Adj. Pay.	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	4.60*	0.27	.001	.22

Five Year Adjustment Intervals

	Fixed	Adj. Pay.	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	6.50*	0.089	0.50	0.54

* Result is significant at the 0.01 level.

Table 7.4 cont.

Potential Call Losses

Comparison By Adjustment Interval

Adjustable Payment Instruments with Payment Cap

	Three Year Capped	Five Year Capped
One Year Capped	17.47*	18.10*
Three Year Capped		2.80*

Payment Capped versus Non-Capped with Longer Interval

	Three Year No Cap	Five Year No Cap
One Year Capped	17.54*	18.06*
Three Year Capped		2.90*

* Results are significant at the 0.01 level.

Potential Delinquency Losses

There are two comparisons of interest for Potential Delinquency Losses. The one year adjustable payment mortgage with a 7.5 percent payment cap has significantly lower Potential Delinquency Losses than either the one or three year adjustable payment mortgages without payment caps. This provides further evidence that payment caps reduce the delinquency risk of an adjustable payment mortgage.

Table 7.5

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Delinquency Losses

	Adj. Pay One Year	Adj. Pay Three Year
One Year Adj. Payment with 7.5 % Pay Cap	4.14*	3.49*

* Results are significant at the 0.01 level.

Potential Market Losses

The Potential Market Losses are not influenced by the presence of payment caps. The primary determinants of market losses are the

Table 7.6

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Market Losses

Comparison By Adjustment Mechanism

One Year Adjustment Interval

	Fixed	Adj. Pay.	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	27.37*	1.76	1.32	1.11

Three Year Adjustment Interval

	Fixed	Adj. Pay.	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	23.77*	0.15	0.07	0.23

Five Year Adjustment Interval

	Fixed	Adj. Pay.	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	18.79*	0.10	0.14	0.41

Adjustable Payment Instruments with Payment Cap

	Three Year Capped	Five Year Capped
One Year Capped	22.59*	26.28*
Three Year Capped		12.02*

Payment Capped versus Non-Capped with Longer Interval

	Three Year No Cap	Five Year No Cap
One Year Capped	22.68*	26.27*
Three Year Capped		11.91*

* Results are significant at the 0.01 level.

adjustment intervals and their related indices. As the length of the interval and maturity of the index increases from one to three to five years, the Potential Market Loss increases significantly regardless of the presence of payment caps. This is to be expected because payment caps do not alter the contract rate of the mortgage, they merely alter the payment pattern. The results indicate that the altered payment pattern is not significantly different from that of a similiar mortgage without payment caps when the measurement tool is the Potential Market Loss.

Internal Rate of Return

The internal rate of return comparison results are similiar to those of the Potential Market Losses in all but one way. The payment cap does not significantly change the internal rate of return for any instrument. This can be explained with the same rational that is used to explain that the payment caps have no impact on Potential Market Losses. The only difference in the two sets of results is that the internal rate of return of mortgage designs with three and five year adjustment intervals are not significantly different regardless of the presence of payment caps.

Table 7.7

Comparison of The Internal Rates of Return
Using Mann-Whitney Z-Statistic

Comparison By Adjustment Mechanism

One Year Adjustment Interval

	Fixed	Adj. Pay.	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	25.30*	1.76	0.21	0.05

Three Year Adjustment Interval

	Fixed	Adj. Pay.	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	27.36*	0.28	0.018	0.24

Five Year Adjustment Interval

	Fixed	Adj. Pay.	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	27.41*	0.06	0.08	0.03

Comparison By Adjustment Interval

Adjustable Payment Instruments with Payment Cap

	Three Year Capped *	Five Year Capped *
One Year Capped	2.96	3.35
Three Year Capped		0.67

Payment Capped versus Non-Capped with Longer Interval

	Three Year No Cap *	Five Year No Cap *
One Year Capped	2.81	3.30
Three Year Capped		0.62

* Results are significant at the 0.01 level.

Conclusions

The impact of payment caps on adjustable payment mortgages is noteworthy. They do not significantly increase Potential Call Losses or Potential Market Losses. They have an insignificant impact on the internal rate of return and reduce Potential Delinquency Losses and Conditional Default significantly. Payment caps of 7.5 percent per period should be included in adjustable payment mortgage designs with one year intervals. Their inclusion in adjustable payment mortgages with three year intervals has less of an impact but may provide an excellent marketing tool with little or no economic cost and some reduction in risk. This implies that an adjustable payment mortgage with a payment cap should carry a lower initial contract rate than an uncapped design to reflect the difference in the level of exposure to delinquency and conditional default risks. This appears to be counter-intuitive on first glance. However, payment caps that allow unlimited negative amortization do not reduce the lender's rate of return. They alter the pattern of the cashflows that generate the return and these results indicate that they increase the return by reducing exposure to delinquency related losses.

Chapter VIII

Neutral Disturbance Terms

The results presented in the two previous chapters are based on an upward bias in the stochastic processes controlling the disturbance terms. This implies that the conclusions drawn from the results must be used with the knowledge that they are based on increasing interest rates, house values and income levels. Over the past few months there has been reason to believe that the upward biases in interest rates, income and house values may not be the appropriate assumptions upon which mortgage designs should be evaluated. There are an infinite number of different assumptions that can be made about the trend of interest rates, house values and income levels into the future. Mortgage designers have to choose the stochastic processes that they believe are going to govern these variables and then design mortgage instruments that accomplish their goals given the chosen processes.

This chapter repeats the Monte Carlo experiment explained in Chapter V with one distinction. The stochastic processes of the interest rate series, income levels and house values are altered. The new stochastic processes are designed to eliminate the upward bias in the series and generate a set of disturbance terms that are trend neutral. The simulation program generates Potential Loss data sets using the new disturbance term generating processes. These data sets are analyzed using the same techniques that are used in Chapter VI and VII. This chapter examines the ten basic mortgage instruments and their impact on

Potential Losses under neutral disturbance terms.

The process used to generate a set of neutral disturbance terms is similiar to that used for the upward biased disturbance terms. Table 5.2 revealed the parameters of the stochastic process used to generate an upward biased set of disturbance terms. These parameters consisted of the mean, standard deviation of the percentage changes of each series. For interest rates, house values and income levels the means were greater than one implying an upward bias. To eliminate the bias the means of each series are set equal to one. This implies an expected monthly change of zero. The other parameters of the stochastic processes remain unchanged.

The impact of the ten mortgage designs upon the Potential Losses under the neutral disturbance terms is examined by using the proportions and Mann-Whitney significance tests. Notice that no comparisons are conducted between Potential Losses generated with the upward biased disturbance terms and Potential Losses generated with the neutral disturbance terms. It is assumed that mortgage designers develop mortgage instruments based on their assumptions about the future of house values, interest rates, and income levels.

The Proportion Results

The proportions calculations were applied to all of the Potential Losses that have positive values. The proportions of the Potential Losses are presented in Table 8.1. This table reveals that the change in the disturbance terms has generated positive values in two of the Potential Loss categories that had none under the upward biased

Table 8.1

The Basic Mortgage Designs Potential Loss Proportions

	Potential Losses					
Instruments	PPL	PCL	Pdl	CDL	CDG	PDL
Fixed Rate	0.046	0.77	0.0	0.0	0.0	0.168
Adj. Payment						
One	0.0	0.792	0.326	0.036	0.126	0.046
Three	0.0	0.976	0.038	0.012	0.0	0.012
Five	0.0	0.968	0.018	0.0	0.012	0.020
Adj. Balance						
One	0.0	0.962	0.0	0.0	0.0	0.038
Three	0.0	0.972	0.0 *	0.0	0.0 *	0.028
Five	0.0	0.978	0.002	0.0	0.002	0.020
Adj. Term						
One	0.0	0.938	0.002 *	0.0	0.002 *	0.060
Three	0.0	0.966	0.0	0.0	0.0	0.034
Five	0.0	0.98	0.002 *	0.0	0.0	0.02

PPL = Potential Put Loss
PCL = Potential Call Loss
PdL = Potential Delinquency Loss
CDL = Conditional Default Loss
CDG = Conditional Default Gain
PDL = Potential Default Loss

*
Not significantly different from zero at the 0.01 level.

disturbance terms. The increase in Potential Default and Conditional Delinquency Losses can be explained by the elimination of the upward bias in house values. Both of these Potential Losses are directly related to house values. Increases in house values reduces the probability of incurring these losses. With the house value upward bias eliminated, these Potential Losses are incurred.

Potential Call Losses

The Potential Call Loss results are broken into three sections for the purpose of discussion. The first section involves the comparisons between the fixed rate mortgage and the other mortgage designs. The second section discusses the results associated with the one year adjustable payment mortgage and the final section discusses the results associated with the one year adjustable term mortgage.

The fixed rate mortgage has a significantly lower proportion of Potential Call Losses than all of the other designs except the one year adjustable payment mortgage. This result can be explained by the three percent prepayment penalty associated with the fixed rate mortgage. It indicates that the prepayment penalty of three percent offsets the length of time over which the borrower's refinancing benefit accrues. The other instruments have a shorter borrower benefit accrual period, but greater volatility in the related index and no prepayment penalty to be overcome.

The one year adjustable payment mortgage result must be analyzed very carefully. On the surface it appears from the results that the proportion of Potential Call Losses of the one year adjustable payment

Table 8.2

Basic Mortgage Design Potential Loss Proportions Z Statistic

Potential Put Loss

	All Other Basic Mortgage Designs
Fixed Rate Mortgage	4.85*

Potential Call Losses

	ADJUSTABLE PAYMENT			ADJUSTABLE BALANCE			ADJUSTABLE TERM		
	ONE	THREE	FIVE	ONE	THREE	FIVE	ONE	THREE	FIVE
Fixed	0.84	9.78*	9.27*	8.91*	9.52*	9.90*	7.52*	9.15*	10.04*
Adj. Pay		*	*	*	*	*	*	*	*
One		9.08	8.56	8.18	8.82	9.21	6.75	8.43	9.35
							*		
Three			0.76	1.27	0.39	0.21	2.96	0.94	0.43
							*		
Five				0.51	0.37	0.97	2.24	0.17	1.19
Adj. Bal.									
One					0.88	1.48	1.74	0.34	1.69
							*		
Three						0.60	2.59	0.54	0.82
							*		
Five							3.15	1.15	0.22
Adj. Term									
									*
One								2.07	3.34
Three									1.36

*
Not significantly different from zero at the 0.01 level.

and fixed rate mortgages are not significantly different. This result is misleading. The other adjustable rate mortgages with one year intervals have significantly higher Potential Call Loss proportions than the fixed rate mortgage. The Potential Call Loss is an interest rate driven loss so there should not be a difference between the Potential Call Losses of mortgage designs with the same adjustment interval. The reason for the difference can be found by examining the other terminal Potential Losses. The one year adjustable payment mortgage has a relatively large exposure to the other terminal Potential Losses. The terminal Potential Losses are mutually exclusive. Therefore, the relatively low rate of Potential Call Losses is not due to the triggering event of Potential Call Losses, but is due to the susceptibility of the one year adjustable payment mortgage to other forms of terminal Potential Losses.

The one year adjustable term mortgage has a significantly lower proportion of Potential Call Losses than the three year adjustable payment, and the three and five year adjustable balance designs. This can be explained by the susceptability of the instruments to other terminal losses. In this case it is the susceptability of the one year adjustable term mortgage to Potential Default Losses that makes the difference.

The Potential Call Loss results indicate that the prepayment penalty for adjustable mortgage designs is needed to reduce the exposure of lenders to Potential Call Losses.

Potential Default Losses

Potential Default Losses are viewed as a borrower's choice not to renew his call option on the house in which he is living. This decision is reached by rational borrowers when the option is out of the money. Being out of the money implies that the value of the house to the borrower is less then the exercise price of the option. The value of the house is its market value less selling costs plus moving costs plus the value of the mortgage to the lender plus the additional cost of future credit due to the default. The exercise price is the remaining balance on the mortgage plus any prepayment penalty. Three of the factors that determine whether a mortgage is out of the money, at the money or, in the money are influenced by the provisions of the mortgage. The remaining balance of the mortgage is influenced by the adjustment mechanism. Adjustable balance and term mortgages can increase or decrease the rate of decline in the mortgage balance. The length of the adjustment interval and the volatility of the adjustment index influence the value of the mortgage to the borrower. Longer adjustment intervals imply a greater absolute value for the mortgage. If the mortgage rate is lower than the current market rate, the mortgage has positive value to the borrower. If the opposite relationship holds the mortgage has negative value to the borrower. The final mortgage provision to influence Potential Default Losses is the prepayment penalty. Higher prepayment penalties increase the probability that the mortgage will be out of the money causing default.

The results indicate that the fixed rate mortgage has a significantly larger proportion of Potential Default Losses than any of

Table 8.3

Potential Default Losses

	ADJUSTABLE PAYMENT			ADJUSTABLE BALANCE			ADJUSTABLE TERM		
	ONE	THREE	FIVE	ONE	THREE	FIVE	ONE	THREE	FIVE
Fixed	6.24	8.61	8.10	6.76	7.44	8.01	5.37	7.03	8.01
Adj. Pay									
One		3.20	2.30	0.63	1.50	2.30	0.98	0.96	2.30
Three			1.00	2.63	1.80	1.00	4.07	2.32	1.00
Five				1.69	0.82	0.0	3.22	1.36	0.0
Adj. Bal.									
One					0.88	1.69	1.61	0.34	1.69
Three						0.82	2.46	0.54	0.82
Five							3.22	1.36	0.0
Adj. Term									
One								1.94	3.22
Three									1.36

* Not significantly different from zero at the 0.01 level.

the adjustable rate mortgages. This can be explained by fixed rate mortgage's prepayment penalty and the length of the adjustment interval. When interest rates fall, the value of the mortgage to the borrower is negative. The size of the negative value is a function of the difference between the contract rate of the mortgage and that of the market and the length of time over which the relationship between the contract rate and the market rate will continue. The value of the mortgage is the present value of the difference between the current payment and that of a market mortgage plus the present value of the difference between the two instrument's remaining balances at the earlier of the expected termination date or the next adjustment period. The fixed rate mortgage has a considerable length of time over which the value of the mortgage accrues. If the contract rate of the mortgage is higher than the market rate, the negative value to the lender can be substantial. If the value of the house is not rising the negative value of the mortgage combined with the prepayment penalty cause rational default. The adjustable rate mortgages have no prepayment penalty and the period over which the value of the mortgage accrues is much shorter, a maximum of fifty-nine months versus one hundred and forty-three months for the fixed rate mortgage.

The results of the Potential Default Loss proportions comparison test indicate that there are no significant differences in the proportion of Potential Losses due to changes in the adjustment mechanism when the adjustment interval is held constant. The results also indicate that there is only one significant change as adjustment interval increases from one to three to five years with the mechanism held constant. This change occurs between the one and five year

adjustable term mortgages. The one year adjustable term mortgage has a significantly higher proportion of Potential Default Losses than the five year adjustable term mortgage. This can be rationalized through a pattern of events. At the twelve month mark the contract rate on the one year adjustable term mortgage is increased. This causes the reduction in the remaining balance of the loan to slow or stop, or reverse. The five year adjustable mortgage continues to have a declining balance because its contract rate has not changed. The result is that the one year instrument meets the conditions for default and the five year does not. The difference in the proportion is rationalized by the increased opportunities for changes in the contract rate that encourage default contained in the one year adjustment interval.

Potential Delinquency Losses

The results of the Potential Delinquency Losses indicate that the adjustable payment mortgages with any adjustment interval have a significantly higher proportion of Potential Delinquency Losses than any of the other mortgages. The differences in the proportion of Potential Delinquency Losses among the other mortgages are insignificant. This finding is easily rationalized. Delinquency is impacted by two variables: the monthly payment and monthly income. All of the instruments are simulated using the same stochastic process to govern the income series. This implies that any difference in the Potential Delinquency Loss proportion is due to changes in the monthly payment. Generally, the only instruments to have monthly payment changes are the

Table 8.4

Potential Delinquency Losses

	ADJUSTABLE PAYMENT			ADJUSTABLE BALANCE			ADJUSTABLE TERM		
	ONE	THREE	FIVE	ONE	THREE	FIVE	ONE	THREE	FIVE
Fixed	13.95	4.40	3.01	0.0	0.0	1.0	1.0	0.0	1.0
Adj. Pay									
One		11.80	12.90	13.95	13.95	13.83	13.83	13.95	13.83
Three			1.91	4.40	4.40	4.06	4.06	4.40	4.06
Five				3.01	3.01	2.54	2.54	3.01	2.54
Adj. Bal.									
One					0.0	1.0	1.0	0.0	1.0
Three						1.0	1.0	0.0	1.0
Five							0.0	1.0	0.0
Adj. Term									
One								1.0	0.0
Three									1.0

* Not significantly different from zero at the 0.01 level.

adjustable payment mortgages. These instruments, due to their adjustment mechanism have a significantly larger proportion of Potential Delinquency Losses than any of the other mortgages. The one year adjustable payment mortgage has a significantly higher proportion of Potential Delinquency Losses than the three or five year adjustment interval adjustable payment designs. This is due to the higher volatility associated with the index of the one year instrument and that it has more opportunities to increase the monthly payment due to the shorter adjustment interval. The three and five year interval designs have Potential Delinquency Loss proportions that are not significantly different.

Conditional Default

Conditional Defaults are caused by the triggering event for Potential Delinquency Losses being met for three consecutive months. The results are broken down into those Conditional Defaults that result in a loss and those that do not result in a loss. The difference between the loss and no loss condition is based on the value of the house. If the market value of the house exceeds the remaining balance of the loan plus the cost to sell the house and the value of the loan to the lender, a Conditional Default Gain is incurred. Otherwise, a Conditional Default Loss is incurred. The one year adjustable payment mortgage has a significantly higher proportion of Conditional Default Losses than any other mortgage. This can be explained by the greater volatility of the one year adjustment interval index and the fact that the one year adjustment interval provides more opportunities for payment increase than any other design. The three year adjustable payment mortgage has a

Table 8.5

Conditional Default Losses

	ADJUSTABLE PAYMENT THREE	All Other Designs
Adj. Pay		
One	2.47*	4.28*
Three		2.45*

Conditional Default Gains

	ADJ. PAYMENT FIVE	ADJ. BALANCE FIVE	ADJ. TERM ONE	ALL OTHERS
Adj. Pay				
One	7.11*	8.01*	8.01*	8.20*
Five		1.89	1.89	2.45
Adj. Bal.				
Five			0.0	1.0
Adj. Term				
One				1.0

* Results are significant at the 0.01 level.

significantly higher proportion of Conditional Default Losses than the five year adjustable payment mortgage. This can be explained by the difference in the volatility of the related indices of the two instruments. No other mortgage has a positive proportion of Conditional Default Losses. Notice that when the housing series contained an upward bias there were no Conditional Default Losses to consider.

Conditional Default Gains are incurred by several instruments. For the reasons stated earlier, the one year adjustable payment mortgage has the highest proportion of Conditional Default Gains. The five year adjustable payment mortgage has a significantly lower proportion of Conditional Default Gains than the one year adjustable payment mortgage. This can be explained by the difference in the volatility of the related indices of the two instruments.

The results of the proportions tests on the Potential Losses of the ten basic instruments simulated under neutral disturbance terms support the conclusions drawn in Chapter VI. There it was concluded that the volatility of the mortgage payment should be restricted by means of a payment cap or extended adjustment interval and that adjustable rate mortgages should be allowed to carry a prepayment penalty to reduce call risk.

The Mann-Whitney Test Results

The Mann-Whitney significance tests are used to measure the impact of various mortgage provisions upon the Potential Losses under neutral disturbance terms. The previous sections disclosed that the neutral disturbance terms activate the Potential Losses associated with delinquency and default. This section explores the relative size of the Potential Losses under neutral disturbance terms. It is not the purpose of this study to measure the impact of a change in disturbance terms on the Potential Losses. This issue could be addressed using the methodology of this study. The impact of different disturbance terms on the risk levels of various mortgage designs may be worthy of future study but it is beyond the scope of the current study. This study reveals the impact of the various mortgage provisions upon the Potential Losses under a given set of disturbance terms.

Potential Call Losses

The Potential Call Losses are incurred by all of the mortgage designs. The comparison tests reveal that the adjustment interval has a larger impact upon the level of the Potential Call Loss than the adjustment mechanism. The adjustable rate mortgages with five year adjustment intervals have significantly higher Potential Call Losses than any of the other instruments. This is not a surprising relationship with the shorter interval adjustable mortgages due to the longer period over which lender losses accrue with the five year adjustable designs. It is surprising that the fixed rate mortgage Potential Call Losses are

Table 8.6

Parameters of Non-Zero Potential Loss Data by Instrument

Fixed Rate Instrument

	Mean	Standard	Low	High
Potential Put Loss	$158.47	89.43	38.72	224.21
Potential Call Loss	$3963.63	3628.40	517.30	13623.16
Pot. Default Loss	$3701.34	1346.21	1020.89	5713.65
Pot. Market Loss	15.74%	13.24	4.15	44.39
Termination Month	31.88	38.45	7.0	156.0
Rate of Return	12.81%	2.78	-1.12	14.87

Adjustable Payment Mortgages

One Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$1545.93	341.01	469.11	2106.06
Pot. Delinquency Loss	$1762.42	409.03	1103.11	2470.63
Cond. Default Loss	$1929.89	1249.28	40.73	3425.58
Cond. Default Gain	$5072.63	2685.67	378.43	9106.92
Pot. Default Loss	$5374.55	580.97	4487.76	5957.02
Pot. Market Loss	0.86%	0.55	0.24	3.68
Termination Month	18.48	14.49	7.0	109.0
Rate of Return	9.52%	1.98	-2.14	11.72

Table 8.6 cont.

Parameters of Non-Zero Potential Loss Data by Instrument

Adjustable Payment Mortgages

Three Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$3796.57	2643.13	888.93	10343.72
Pot. Delinquency Loss	$1280.11	330.10	929.66	1717.73
Cond. Default Loss	$747.17	155.42	605.25	889.09
Pot. Default Loss	$4792.54	105.37	4696.34	4888.75
Pot. Market Loss	2.80%	1.69	0.96	8.40
Termination Month	13.61	10.56	7.0	75.0
Rate of Return	10.83%	0.61	6.98	11.75

Five Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$5019.89	4108.74	826.90	16730.90
Pot. Delinquency Loss	$943.67	161.32	741.28	1107.96
Cond. Default Gain	$2297.58	307.29	2016.98	2578.11
Pot. Default Loss	$4915.86	50.17	4857.71	4960.05
Pot. Market Loss	4.64%	3.28	1.72	14.47
Termination Month	13.40	10.97	7.0	63.00
Rate of Return	10.83%	0.60	7.21	11.80

Table 8.6 cont.

Parameters of Non-Zero Potential Loss Data by Instrument

Adjustable Balance Mortgages

One year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$1411.80	414.46	201.10	2104.18
Pot. Default Loss	$5563.38	619.42	5049.29	6533.62
Pot. Market Loss	1.04%	1.07	0.24	6.33
Termination Month	19.85	20.55	7.0	121.0
Rate of Return	10.39%	1.34	5.68	12.84

Three Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$3813.09	2728.14	763.91	10343.72
Pot. Default Loss	$4784.43	87.36	4696.30	4888.75
Pot. Market Loss	2.86%	1.83	0.96	10.65
Termination Month	13.93	11.13	7.0	75.0
Rate of Return	10.85%	0.66	6.98	12.73

Table 8.6 cont.

Parameters of Non-Zero Potential Loss Data by Instrument

Adjustable Balance Mortgages

Five Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$4899.99	4035.32	672.91	16430.90
Pot. Delinquency Loss	$981.33	0.0	981.33	981.33
Cond. Default Gain	$2584.05	0.0	2584.05	2584.05
Pot. Default Loss	$4924.96	46.62	4857.62	4959.97
Pot. Market Loss	4.69%	3.40	1.72	16.12
Termination Month	13.68	11.86	7.0	74.0
Rate of Return	10.84%	0.63	7.21	12.18

Adjustable Term Mortgage

One Year Adjustment Period

	Mean	Standard Deviation	Low	High
Potential Call Loss	$1442.33	398.55	234.84	2096.32
Pot. Delinquency Loss	$1092.35	0.0	1092.35	1092.35
Cond. Default Gain	$3253.01	0.0	3253.01	3253.01
Pot. Default Loss	$5665.05	879.80	4063.23	6580.83
Pot. Market Loss	1.05%	0.95	0.24	6.33
Termination Month	19.93	18.16	7.0	111.00
Rate of Return	10.23%	1.60	2.39	12.84

Table 8.6 cont.

Parameters of Non-Zero Potential Loss Data by Instrument

Adjustable Term Mortgages

Three Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$3751.11	2632.89	763.91	10343.71
Pot. Default Loss	$4889.53	255.52	4696.34	5400.88
Pot. Market Loss	2.83%	1.77	0.96	10.84
Termination Month	13.78	10.72	7.0	75.0
Rate of Return	10.86%	0.66	6.98	12.73

Five Year Adjustment Interval

	Mean	Standard Deviation	Low	High
Potential Call Loss	$4862.58	4025.01	672.91	16430.90
Pot. Delinquency Loss	$725.85	0.0	725.85	725.85
Pot. Default Loss	$4926.11	47.36	4857.79	4960.05
Pot. Market Loss	4.73%	3.34	1.72	16.12
Termination Month	13.66	11.47	7.0	74.0
Rate of Return	10.85%	0.63	7.21	12.18

significantly lower than those of the five year adjustable rate

mortgages. This indicates that the prepayment penalty of the fixed rate mortgage has a significant impact on the level of the Potential Call Losses incurred by lenders. The fact that the fixed rate mortgage Potential Call Losses are not significantly different from the three year adjustable term and balance Potential Call Losses is an even greater indication of the importance that prepayment penalties play in reducing call losses.

The differences in the Potential Call Losses between the adjustable rate mortgages with different adjustment mechanisms but the same adjustment interval is not significant in all but one case. The one year adjustable payment mortgage has significantly higher Potential Call Losses than the one year adjustable term and balance mortgages. This can be explained by the difference in monthly payment pattern. The adjustable payment mortgage could have a substantial payment increase to reflect an increase in the index rate. The adjustable term and balance mortgages would reflect the increase in the index rate by altering the pattern of principal amortization. If the index rate falls enough to cause a rational mortgage call, a Potential Call Loss is created. The size of the Potential Call Loss is greater for the adjustable payment mortgage than for the adjustable term and balance due to the timing cf the cashflows associated wikth the loss. The adjustable payment mortgage generates a loss that is composed primarily of the difference in the monthly payments. The adjustable term and balance loss is primarily related to the difference in the size of the remaining balance at the next adjustment point. The Potential Call Loss calculation requires that these amounts be discounted to the mortgage origination date. The

Table 8.7

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Call Losses

Comparison By Adjustment Mechanism

One Year Adjustment Intervals

	Adj. Payment *	Adj. Balance *	Adj. Term *
Fixed	9.73	12.46	11.97
Adj. Payment		4.87	3.80
Adj. Balance			1.00

Three Year Adjustment Intervals

	Adj. Payment *	Adj. Balance	Adj. Term
Fixed	2.58	2.14	2.19
Adj. Payment		0.28	0.23
Adj. Balance			0.04

Five Year Adjustment Intervals

	Adj. Payment *	Adj. Balance *	Adj. Term *
Fixed	5.84	5.49	5.39
Adj. Payment		0.38	0.59
Adj. Balance			0.23

Table 8.7 cont.

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Call Losses

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Interval	Five Year Interval
	*	*
One Year Interval	16.44	19.31
		*
Three Year Interval		3.96

Adjustable Balance Instruments

	Three Year Interval	Five Year Interval
	*	*
One Year Interval	18.10	21.22
		*
Three Year Interval		3.86

Adjustable Term Instruments

	Three Year Interval	Five Year Interval
	*	*
One Year Interval	18.09	20.85
		*
Three Year Interval		3.56

payment differences are recognized earlier in the mortgage life, therefore the impact of discounting is less. This creates the difference in the Potential Call Losses between the one year adjustable payment and the one year adjustable balance and term mortgages.

The final set of comparisons are between mortgage designs with the same adjustment mechanisms but different adjustment intervals. As the interval increases from one to three to five years, the Potential Call Losses increase significantly. This can be explained by the increased period over which the lender's loss accrues. The decrease in the volatility of the related index does not hinder the accumulation of the lender's loss as much as the increased loss accrual period enhances the Potential Call Loss. It is interesting to note that these results are very similiar to the results generated by upwardly biased disturbance terms.

Potential Delinquency Losses

The Mann-Whitney significance test is applied to a limited number of the mortgage designs because many of the instruments do not incur Potential Delinquency Losses. As Table 8.4 shows size of the loss is not related to the adjustment mechanism. The Potential Delinquency Losses of the one and five year adjustable term and payment mortgages are not significantly different. This result can be explained by the restriction placed on Potential Delinquency Losses due to Conditional Default. Once a mortgage instrument meets a delinquency condition it must either enter Conditional Default or a normal payment pattern within three months. This limits the exposure of an instrument to Potential Delinquency

Table 8.8

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Delinquency Losses

Comparison By Adjustment Mechanism

Five Year Adjustment Intervals

	Adjustable Balance	Adjustable Term
Adj. Payment	0.53	1.59
Adj. Balance		1.00

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Interval	Five Year Interval
One Year Interval	4.54 *	4.94 *
Three Year Interval		2.29

Adjustable Term Instruments

	Three Year Interval	Five Year Interval
One Year Interval	n.a.	1.0

Losses.

There is a significant difference in the size of the Potential Delinquency Losses between the one year adjustable payment and the three and five year adjustable payment mortgages. This difference can be explained by the differences in the adjustment intervals and their related indices. The one year instrument has a more volatile index and a shorter adjustment interval. This creates more opportunity for payment increases that lead to the triggering events of Potential Delinquency Losses. When triggered the monthly payments missed may be larger than those of three and five year interval mortgages because the three and five year mortgages have had less opportunity to increase their payments.

Conditional Default Losses

The presence of Conditional Default Losses can be attributed to the stochastic process governing the housing series. Without the upward bias in the housing series the net value of the house does not always exceed the value of the mortgage to the lender. The size of the Conditional Default Losses are not significantly different for the one and three year adjustable payment mortgages. These are the only instruments to incur Conditional Default Losses.

Conditional Default Gains

The Conditional Default Gain measures the total impact of a mortgage foreclosure due to rational delinquency. If the mortgage contract rate is above the market required contract rate the mortgage value is positive and if the mortgage contract rate is below the market

Table 8.9

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Conditional Default Losses

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Interval	Five Year Interval
One Year Interval	2.00	n.a.

Conditional Default Gains

Comparison By Adjustment Mechanism

Five Year Adjustment Intervals

	Adj. Payment	Adj. Balance	Adj. Term
Adj. Payment		1.51	n.a.

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Interval	Five Year Interval
One Year Interval	n.a.	2.36*

required contract rate, the mortgage has negative value to the lender. The Conditional Default Gain measures the opportunity and actual gain attributed to a mortgage foreclosure caused by delinquency. The opportunity gain to the lender is the present value of the difference

between the market required monthly payments and those of the outstanding mortgage until the next adjustment point or expected termination date plus the difference in the remaining balance at the next adjustment point or expected termination date when the market contract rate is higher than the current contract rate on the mortgage. The foreclosure puts the lender in a better position by eliminating a below market investment for a net price greater than the market value of the mortgage. The proportion of Conditional Default Gains has more significance than their size because the lender cannot retain more than the remaining balance and foreclosure costs from the proceeds generated by the sale of the mortgaged house. This measure gives an indication of the size of the cushion created by changes in house values when the mortgage enters Conditional Default. The size of the Conditional Default Gain does not change significantly across adjustment mechanisms when the adjustment interval is held constant. When the adjustment mechanism is held constant and the interval is varied, the one year adjustable payment mortgage is found to have a significantly higher Conditional Default Gain than the five year adjustable payment mortgage. This can be explained by the difference in the amortization patterns of the two mortgages. The pattern of the five year mortgage has less opportunity to change.

Potential Default Losses

Potential Default Losses measure the losses incurred by lenders due to rational economic default. The components of the loss include the difference between the market value of the house net of selling costs

Table 8.10

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Default Losses

Comparison By Adjustment Mechanism

One Year Adjustment Intervals

	Adj. Payment *	Adj. Balance *	Adj. Term *
Fixed	5.67	5.83	6.11
Adj. Payment		0.56	2.20
Adj. Balance			1.27

Three Year Adjustment Intervals

	Adj. Payment	Adj. Balance *	Adj. Term *
Fixed	2.23	3.26	3.84
Adj. Payment		0.24	0.70
Adj. Balance			0.69

Five Year Adjustment Intervals

	Adj. Payment *	Adj. Balance *	Adj. Term *
Fixed	4.16	4.16	4.16
Adj. Payment		0.85	0.91
Adj. Balance			1.09

Table 8.10 cont.

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Interval	Five Year Interval
One Year Interval	1.77	1.37
Three Year Interval		1.95

Adjustable Balance Instruments

	Three Year Interval	Five Year Interval
One Year Interval	4.84 *	4.36 *
Three Year Interval		3.39 *

Adjustable Term Instruments

	Three Year Interval	Five Year Interval
One Year Interval	3.32 *	2.81 *
Three Year Interval		2.31

and the remaining balance of the mortgage plus the value of the loan to the lender. The selling costs are assumed to be seven percent of the house value and the value of the loan to the lender is the difference between the present value of the current mortgage payment and the market required payment until the next adjustment point or the expected termination date plus the present value of the difference between the current mortgage's remaining balance at the next adjustment point or expected termination date and that of the market mortgage.

The results indicate that the fixed rate mortgage has significantly lower Potential Default Losses than the adjustable rate mortgages. This can be explained by the triggering events of rational economic default. Rational economic default views the mortgage contract as a call option to purchase the mortgaged house for the remaining balance plus the prepayment penalty. If the market value of the house plus the value of the loan to the borrower is less than the value of avoiding default, the borrower defaults. The value of avoiding default includes the remaining balance plus any prepayment penalty, moving expenses and implied future credit costs. This implies that the value of the house does not have to fall as much with fixed rate mortgages as it does with adjustable rate mortgages due to the prepayment penalty to meet the necessary conditions for rational economic default. This causes the Potential Default Losses of fixed rate mortgages to be smaller than those of adjustable rate mortgages.

The results also indicate that size of the Potential Default Losses increases as the adjustment interval decreases from five to three to one year for adjustable term and balance mortgages. This can be

explained by the combination of the adjustment mechanism of these instruments and the declining interval. When interest rates rise the adjustable term and balance mortgages respond by decreasing the rate at which the remaining balance is amortized. The one year adjustment interval mortgage has the most opportunities to have a contract rate that exceeds the original contract rate. This implies that the one year instrument has the greatest opportunities for a slowdown in the amortization of the remaining balance. If default should occur after such a slow down, the loss associated with the default will be larger due to the larger remaining balance. Longer adjustment intervals cause the amortization rate to remain stable for longer periods reducing the remaining balance and therefore the size of the Potential Default Loss. In general mortgages that rely on adjustments to the mortgage balance or term have larger Potential Default Losses as their adjustment interval decreases.

Potential Market Losses

The Potential Market Losses under the neutral disturbance terms have the same relationships across mortgage designs that were found with the upward biased disturbance terms. The fixed rate mortgage has a significantly higher Potential Market Loss than any of the other mortgage designs. The impact of the adjustment mechanism upon Potential Market Losses is insignificant. The impact of increases in the adjustment interval from one to three to five years causes significant increases in the Potential Market Losses. These results are consistent

Table 8.11

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Potential Market Losses

Comparison By Adjustment Mechanism

One Year Adjustment Intervals

	Adj. Payment *	Adj. Balance *	Adj. Term *
Fixed	27.37	26.66	26.96
Adj. Payment		0.27	0.95
Adj. Balance			1.13

Three Year Adjustment Intervals

	Adj. Payment *	Adj. Balance *	Adj. Term *
Fixed	22.90	22.48	22.68
Adj. Payment		0.14	0.19
Adj. Balance			0.03

Five Year Adjustment Intervals

	Adj. Payment *	Adj. Balance *	Adj. Term *
Fixed	17.51	17.58	17.11
Adj. Payment		0.02	0.44
Adj. Balance			0.42

Table 8.11 cont.

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Interval	Five Year Interval
One Year Interval	22.78 *	26.76 *
Three Year Interval		11.14 *

Adjustable Balance Instruments

	Three Year Interval	Five Year Interval
One Year Interval	20.95 *	24.49 *
Three Year Interval		10.91

Adjustable Term Instruments

	Three Year Interval	Five Year Interval
One Year Interval	20.51 *	24.41 *
Three Year Interval		11.35

with the duration of each of the mortgage designs and its impact on market price volatility.

Internal Rate of Return

The internal rate of return results presented in Table 8.4 indicate that the fixed rate mortgage has a significantly higher rate of return than any of the adjustable rate mortgages. Two factors explain this result. First the fixed rate mortgage maintains a cashflow pattern throughout its life that is based on the initial contract rate. The only time the return on a fixed rate mortgage can be lower than the contract rate is when there is a default or delinquency condition. Under Potential Call Losses the return on the fixed rate mortgage actually increases due to the prepayment penalty. The fixed rate mortgage has a significantly higher rate of return than the other mortgage designs due to its cashflow pattern and its prepayment penalty.

It should also be remembered that the pattern of interest rates contributes to this result. In Chapter VI, the impact of the relationship between the interest rate series, the initial contract rate, and the internal rate of return was discussed. This discussion applies here also.

The internal rate of return for the one year adjustable payment mortgage is significantly lower than that of the one year adjustable term and balance mortgages. This is explained by the proportion and size of the Potential Losses associated with the one year adjustable payment mortgage. Over eight percent of its iterations are terminated with default losses and over thirty two percent of its iterations incur

Table 8.12

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Internal Rate of Return

Comparison By Adjustment Mechanism

One Year Adjustment Intervals

	Adj. Payment	Adj. Balance	Adj. Term
	*	*	*
Fixed	21.20	19.34	19.77
		*	*
Adj. Payment		9.23	7.90
Adj. Balance			0.96

Three Year Adjustment Intervals

	Adj. Payment	Adj. Balance	Adj. Term
	*	*	*
Fixed	19.28	19.14	19.09
Adj. Payment		0.40	0.48
Adj. Balance			0.12

Five Year Adjustment Intervals

	Adj. Payment	Adj. Balance	Adj. Term
	*	*	*
Fixed	19.24	19.20	19.19
Adj. Payment		0.03	0.47
Adj. Balance			0.43

Table 8.12 cont.

Comparison of Non-Zero Potential Loss Data Using Mann-Whitney Z-Statistics

Comparison By Adjustment Interval

Adjustable Payment Instruments

	Three Year Interval *	Five Year Interval *
One Year Interval	16.94	16.97
Three Year Interval		0.10

Adjustable Balance Instruments

	Three Year Interval *	Five Year Interval *
One Year Interval	6.23	6.17
Three Year Interval		0.23

Adjustable Term Instruments

	Three Year Interval *	Five Year Interval *
One Year Interval	6.85	6.88
Three Year Interval		0.02

delinquency losses. These losses cause the lower expected internal rate of return for the adjustable payment mortgage.

The adjustment interval has a positive impact on the internal rate of return. As the interval increases the internal rate of return increases. This can be explained by recognizing that the cashflow pattern remains constant for a longer period of time with the longer adjustment intervals. Therefore, the rate of return of these instruments is less likely to deviate from the initial contract rate. Also, the mortgages with longer adjustment periods incur fewer Potential Losses. Less losses imply a higher expected rate of return.

Conclusions

The results of the Mann-Whitney significance tests and the proportions tests using data generated by the simulation program with neutral disturbance terms reveal that some of the Potential Losses have a stonger relationship with the disturbance terms than they do with the mortgage designs. This is particularly true in the case of Potential Losses associated with default, delinquency and foreclosure. The results of the Potential Losses associated with changes in interest rates are similiar to those found in Chapter VI. Prepayment penalties should be designed into adjustable rate mortgages to reduce their exposure to Potential Call Losses. It should also be noted that the impact of changing the means of the interest rate disturbance term percentage change series did not alter the conclusions drawn from the results of the Potential Losses that are based upon interest rate movement. This implies that the volatility of interest rate series, an unchanged

variable, may be the significant component in the impact of interest rates on the Potential Losses. This issue can be explored using the methodology presented in this work in the same manner as the change in the bias of the disturbance terms was accomplished here. This issue is left for future research.

Chapter IX

The Impact of A Per Period Payment Cap Under Neutral Disturbance Terms

In Chapter VII the impact of a per period payment cap under upward biased disturbance terms is presented. Chapter VIII presents the impact of the ten basic mortgage designs under neutral disturbance terms. Under the neutral disturbance terms there is an increase in the Potential Losses related to payment burden. This Chapter reveals the impact of payment caps upon the Potential Losses under neutral disturbance terms. The payment cap to be examined is the same one examined in Chapter VII, the 7.5 percent per period limit on increases in the monthly payment. The impact of this mortgage provision is analyzed by the proportions Z statistic to determine if it changes the probability of incurring a Potential Loss and by the Mann-Whitney Z statistic to determine if the payment cap changes the size of Potential Losses that are incurred.

The Proportions Test

Table 9.1 presents the proportions of the Potential Losses that are incurred by the adjustable payment mortgages with a 7.5% payment cap. The Potential Losses incurred are Potential Call Losses, Potential Delinquency Losses and Potential Default Losses. Notice that Conditional Defaults are not incurred. This implies that the payment cap reduces the exposure of adjustable payment mortgages for risks associated with payment burden.

The comparisons of the proportions of the Potential Call Losses

Table 9.1

Potential Loss Proportions for Adjustable Payment Mortgages with a 7.5% Per Period Payment Increse Cap

	Potential Loss		
Adj. Interval	PCL	PdL	PDL
One Year	0.912	0.294	0.088
Three Year	0.988	0.028	0.012
Five Year	0.980	0.012	0.020

PCL = Potential Call Loss
PdL = Potential Delinquency Loss
PDL = Potential Default Loss

Table 9.2

Potential Loss Proportions Comparison Statistics

Potential Call Losses

Comparison By Adjustment Mechanism

One Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with 7.5% Pay Cap	6.14	5.34	3.25	1.56

Three Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with 7.5% Pay Cap	10.56	1.42	1.80	2.32

Five Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with 7.5% Pay Cap	10.04	1.19	0.221	0.0

Comparison By Adjustment Interval

	Three Year Pay Cap	Five Year Pay Cap
One Year Adj. Pay with 7.5% Pay Cap	5.51	4.75
Three Year Adj. Pay with 7.5% Pay Cap		1.00

reveal that the payment cap has its greatest impact on the one year adjustment period mortgages. The capped adjustable payment mortgage has a significantly higher proportion of Potential Call Losses than the uncapped adjustable payment mortgage with a one year adjustment interval. It should be remembered that the relatively low proportion of Potential Call Losses of the one year adjustable payment mortgage was explained in Chapter VII by examining the other terminal Potential Losses. At that time the lower proportion of Potential Call Losses was attributed to the relatively high proportion of terminal payment burden related Potential Losses. The significant increase in the proportion of Potential Call Losses caused by the payment cap provision is directly related to the elimination of exposure to terminal payment burden Potential Losses. The payment cap does not have a significant impact on the proportion of Potential Call Losses of adjustable payment mortgages with three and five year adjustment intervals. The one year adjustable payment mortgage with the payment cap has a significantly lower proportion of Potential Call Losses than either the three or five year adjustable payment mortgages with payment caps. This difference can be attributed to the greater volatility associated with the one year adjustable mortgage indices.

The proportion of Potential Delinquency Losses of the adjustable payment mortgages with the 7.5% payment cap are not significantly different from the Potential Delinquency Loss proportions of the adjustable payment mortgages without the payment caps and the same adjustment interval. This implies that the 7.5% payment caps do not reduce the proportion of Potential Delinquency Losses. The proportion of

Table 9.3

Potential Loss Proportions Comparison Statistics

Potential Delinquency Losses

Comparison By Adjustment Mechanism

One Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with 7.5% Pay Cap	13.12	1.09	13.12	13.00

Three Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with 7.5% Pay Cap	3.76	0.88	3.76	3.76

Five Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with 7.5% Pay Cap	2.45	0.78	1.89	1.89

Comparison By Adjustment Interval

	Three Year Pay Cap	Five Year Pay Cap
One Year Adj. Pay with 7.5% Pay Cap	11.43	12.38
Three Year Adj. Pay with 7.5% Pay Cap		1.80

Potential Delinquency Losses of the adjustable term, balance and fixed rate mortgage remain significantly lower than those the adjustable payment with or without payment caps in all adjustment intervals except the five year interval. The Potential Delinquency Loss proportions of all mortgage designs with five year adjustment periods are not significantly different. The final set of comparisons reveal that the one year adjustable payment mortgage with a payment cap has a significantly higher proportion of Potential Delinquency Losses than the same mortgage with three or five year adjustment intervals. Further, there is not a significant difference in the proportion of Potential Delinquency Losses between the three and five year adjustment interval designs. These results indicate that the 7.5% payment caps do not significantly reduce the proportion of Potential Delinquency Losses. It should be noted that the proportion of Conditional Default Losses and Gains are significantly reduced by the 7.5% payment cap indicating that the delinquencies that are incurred are of a reduced severity and duration.

The proportion of Potential Default Losses of the one year adjustable payment mortgage with payment caps are significantly higher than those of the one year adjustable payment mortgage without payment caps. The triggering event of Potential Default Losses is a function of the remaining balance of the mortgage, the net house value and the value of the mortgage to the borrower. The reason the adjustable payment mortgage with payment caps increases the proportion of Potential Default Losses is that it contains two components that contribute to rational default. The first is the size of the monthly payment. Under the

Table 9.4

Potential Loss Proportions Comparison Statistics

Potential Default Losses

Comparison By Adjustment Mechanism

One Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with 7.5% Pay Cap	3.78	2.65	3.25	1.69

Three Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with 7.5% Pay Cap	8.61	0.0	1.80	2.32

Five Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with 7.5% Pay Cap	8.01	0.0	0.0	0.0

Comparison By Adjustment Interval

	Three Year Pay Cap	Five Year Pay Cap
One Year Adj. Pay with 7.5% Pay Cap	5.51	4.75
Three Year Adj. Pay with 7.5% Pay Cap		1.00

adjustable payment mortgage the monthly payment can increase causing a negative value for the mortgage if the market rate declines.

The second is the reduced amortization rate that can accompany increases in the contract rate. Assume a mortgage contract rate increases enough to imply a monthly payment that is higher than that allowed by the payment cap. The rate at which the balance of the mortgage declines slows to reflect the shortfall in the monthly payment. This creates a larger balance in the future coupled with larger monthly payments. If the market required contract rate should fall, the remaining balance will be relatively large and the value of the mortgage to the borrower will be negative. The combination of the impact of a larger remaining balance and larger monthly payments causes an increase in the proportion of Potential Default Losses. This is the same reason that there is a significant difference between the proportions of the one year adjustable payment with a payment cap and the one year adjustable balance.

The final comparison presented in Table 9.2 of the Potential Default Losses is between the adjustable payment mortgages with payment caps but different length intervals. The results of these comparisons reveal that the one year adjustable payment mortgage with the 7.5% payment cap has a significantly higher proportion of Potential Default Losses than the three or five year interval designs. This can be explained by the differences in the volatility of the related indices and the different payment and remaining balance patterns. The one year mortgage has the most opportunites to generate payment changes and reductions in the rate of decline in the remaining balance. The

combination of these events causes an increase in the proportion of default losses.

The proportions tests reveal that the presence of a 7.5% payment cap does have a significant impact on the performance of the one year adjustable payment mortgage. The payment cap eliminates Conditional Default but does not significantly change the proportion of Potential Delinquency Losses. It also causes an increase in the proportion of Potential Default Losses and Potential Call Losses. The Potential Call Loss results are the consequence of the reduction in Conditional Defaults. The importance of the impact of the payment caps is disclosed by looking at the size of the Potential Losses.

The Mann-Whitney Significance Tests

The size of the Potential Call Losses of adjustable payment mortgages is not significantly impacted by the presence of a 7.5% payment cap. Comparing the adjustable payment mortgages with payment caps across adjustment intervals reveals that as the interval increases so does the size of the Potential Call Loss. These findings are consistent with those of Chapter VII. The same rationalization applies.

The size of Potential Delinquency Losses of adjustable payment mortgages with 7.5% payment caps is significantly less than those of uncapped adjustable payment mortgages with the same adjustment intervals. This reflects the reduction in payment burden that is the result of the payment cap. The adjustable payment mortgage with the 7.5% payment cap and a one year adjustment interval has significantly higher Potential Delinquency Losses than the same mortgage design with three

Table 9.5

Parameters of Non-Zero Potential Loss Data

One Year Adjustable Payment with 7.5% Per Period Pay Cap

	Mean	Standard Deviation	Low	High
Potential Call Loss	$1549.99	364.96	518.69	2120.58
Pot. Delinquency Loss	$621.01	8.74	603.99	642.26
Pot. Default Loss	$5745.82	728.88	4813.61	7026.12
Pot. Market Loss	0.82%	0.53	0.24	3.39
Termination Month	18.80	16.41	7.00	111.00
Rate of Return	9.74%	2.49	-4.13	12.52

Parameters of Non-Zero Potential Loss Data

Three Year Adjustable Payment with 7.5% Per Period Pay Cap

	Mean	Standard Deviation	Low	High
Potential Call Loss	$3797.64	2615.55	888.97	10343.72
Pot. Delinquency Loss	$454.19	2.80	449.71	457.47
Pot. Default Loss	$4792.53	105.39	4696.30	4888.75
Pot. Market Loss	2.81%	1.71	0.96	8.36
Termination Month	13.81	10.85	7.00	75.00
Rate of Return	10.85%	0.61	6.98	12.06

Table 9.5 cont.

Parameters of Non-Zero Potential Loss Data

Five Year Adjustable Payment with 7.5% Per Period Pay Cap

	Mean	Standard Deviation	Low	High
Potential Call Loss	$4935.17	4077.84	826.96	16430.90
Pot. Delinquency Loss	$339.23	8.58	331.39	347.07
Pot. Default Loss	$4952.30	48.72	4858.35	4961.03
Pot. Market Loss	4.67%	3.31	1.72	14.14
Termination Month	13.59	11.48	7.00	74.00
Rate of Return	10.84%	0.62	7.21	12.05

and five year adjustment intervals. This is due to the difference in the volatility of the adjustment mechanism and the frequency of the payment changes. Comparing the capped payment mortgages to adjustable payment mortgages without caps and longer adjustment intervals reveals that Potential Delinquency Losses of the capped mortgage with a one year interval are significantly lower than those of the uncapped mortgage with three and five year intervals. Further, the three year capped design has a significantly lower Potential Delinquency Loss level than the five year uncapped design. These results indicate that the payment cap is a more effective way to reduce Potential Delinquency Loss than extending the adjustment interval, another way of reducing Potential Delinquency Losses.

The results of the Potential Default Loss size comparisons reveal that the fixed rate mortgage has significantly lower Potential Default Losses than any of the adjustable rate mortgages. The results also indicate that there are no significant differences between the uncapped payment, term and balance mortgages and the capped adjustable payment mortgage as long as the adjustment interval is the same. The only significant differences in the size of the Potential Default Losses are found between the one year capped adjustable payment mortgage and the capped and uncapped three and five year adjustment mortgages. This result is due to the hybrid nature of the adjustable payment mortgage with a payment cap. The one year interval provides greater opportunities for payment and amortization changes. These changes can result in increased monthly payments yielding a higher opportunity loss to the lender upon default and a higher remaining balance. The combination of a

high balance and a high monthly payment causes large Potential Default Losses. In general the results indicate that the 7.5% payment cap has a limited impact on the size of Potential Default Losses.

The Potential Market Loss comparison reveals that the adjustable payment mortgages with the 7.5% payment caps are not significantly different from other adjustable mortgage designs with the same adjustment intervals. As the interval increases from one to three to five years, the size of the Potential Losses increases. This is as to be expected because the payment cap only alters the cashflow vector associated with the mortgage and not the contract ratre that establishes the cashflow vector. The 7.5% payment cap does not alter the Potential Market Losses of a mortgage design.

The last set of comparisons is between the internal rates of return of the various mortgage designs. The results indicate that the internal rate of return of the one year adjustable payment mortgage with the 7.5% paymnet cap is significantly higher than the return on the one year adjustable payment mortgage without the cap. This can be explained by the larger number of mortgage terminations due to default and conditional default associated with the uncapped mortgage. These terminations generate relatively small terminal cashflows and they reduce the rate of return. There are no other significant differences in the rate of return associated with differing adjustment mechanisms. The results indicate that the payment cap improves the rate of return for one year adjustable payment mortgages by reducing their exposure to delinquency related losses.

The Mann-Whitney comparisons have revealed that the one year adjustable payment mortgage is positively impacted by the addition of a 7.5% per period payment cap. The impact of the cap on mortgages with longer interval is very limited.

Table 9.6

Comparison of Non-Zero Potential Loss Data
Using Mann-Whitney Z Statistic

Potential Call Loss

Comparison By Adjustment Mechanism

One Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	10.23	0.32	5.19	4.04

Three Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	2.68	0.20	0.51	0.49

Five Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	5.54	0.36	0.01	0.23

Table 9.6 cont.

Comparison By Adjustment Interval

Adjustable Payment Instruments with Payment Caps

	Three Year Capped	Five Year Capped
One Year Capped	17.35	19.62
Three Year Capped		3.37

Adjustable Payment Capped Versus Non-Capped with Longer Intervals

	Three Year No Cap	Five Year No Cap
One Year Capped	16.99	19.89
Three Year Capped		3.81

Table 9.7

Potential Delinquency Loss

One Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	n.a.	15.20	n.a.	1.72

Three Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	n.a.	4.86	n.a.	n.a.

Five Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	n.a.	3.21	1.57	1.57

Comparison By Adjustment Interval

Adjustable Payment Instruments with Payment Caps

	Three Year Capped	Five Year Capped
One Year Capped	6.17	4.14
Three Year Capped		

Adjustable Payment Capped Versus Non-Capped with Longer Intervals

	Three Year No Cap	Five Year No Cap
One Year Capped	7.08	5.02
Three Year Capped		4.00

Table 9.8

Potential Default Losses

One Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	8.16	1.48	1.37	0.83

Three Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	2.23	0.08	0.24	0.80

Five Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	4.16	0.38	0.15	1.25

Comparison By Adjustment Interval

Adjustable Payment Instruments with Payment Caps

	Three Year Capped	Five Year Capped
One Year Capped	3.58	4.00
Three Year Capped		1.87

Adjustable Payment Capped Versus Non-Capped with Longer Intervals

	Three Year No Cap	Five Year No Cap
One Year Capped	3.58	4.00
Three Year Capped		1.96

Table 9.9

Potential Market Losses

One Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	27.37	1.33	0.64	1.98

Three Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	22.53	0.12	0.02	0.07

Five Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	17.53	0.04	0.01	0.40

Comparison By Adjustment Interval

Adjustable Payment Instruments with Payment Caps

	Three Year Capped	Five Year Capped
One Year Capped	23.86	26.49
Three Year Capped		11.22

Adjustable Payment Capped Versus Non-Capped with Longer Intervals

	Three Year No Cap	Five Year No Cap
One Year Capped	23.87	26.49
Three Year Capped		11.22

Table 9.10

Internal Rate of Return

One Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	20.35	6.61	2.99	2.08

Three Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	19.24	0.35	0.08	0.18

Five Year Adjustment Interval

	Fixed	Adj. Pay	Adj. Bal.	Adj. Term
Adj. Pay with Pay Cap	19.22	0.16	0.11	0.32

Comparison By Adjustment Interval

Adjustable Payment Instruments with Payment Caps

	Three Year Capped	Five Year Capped
One Year Capped	9.95	9.77
Three Year Capped		0.00

Adjustable Payment Capped Versus Non-Capped with Longer Intervals

	Three Year No Cap	Five Year No Cap
One Year Capped	9.79	9.74
Three Year Capped		0.19

Chapter X

Conclusions

The growing importance of Adjustable Rate Mortgages in the portfolios of America's financial institutions and their impact on the exposure of these institutions to changes in interest rates, house values and income levels motivated this study. In general this study examines the impact of new mortgage provisions upon the quality of mortgage loans. The quality of a mortgage is measured by the probability and size of Potential Losses generated by the mortgage instrument. Potential Losses are surrogate measures for the systematic mortgage risks associated with changes in the condition of the mortgage. The Potential Losses measure delinquency risk, default risk, premature termination or call risk, late termination or put risk and residual interest rate or market risk.

Chapter II discusses the Adjustable Mortgage Loan regulations and a number of possible mortgage provisions and designs. Chapter III reviews the literature about mortgage risks for fixed and adjustable rate mortgages. Chapter IV develops the Potential Loss risk measures. It explains the necessary conditions for each type of Potential Loss and how the loss is calculated. Chapter V presents the Monte-Carlo experiment that is used to implement the Potential Loss model. Chapters VI through IX discuss the impact of various mortgage provisions upon each of the Potential Losses under two sets of disturbance terms. The first set is biased upward and the second set has a neutral bias.

The most significant results can be summarized in three conclusions. First, the presence of a prepayment penalty significantly alters the distribution of Potential Call Losses. Therefore, adjustable rate mortgages should be allowed to contain prepayment penalties. Second, the volatility of monthly payments should be restricted by lenders to reduce delinquency risk. This can be done by increasing the adjustment interval or including payment caps on adjustable payment mortgages. Third, there is an inverse relationship between the length of the adjustment interval and the amount of delinquency and default risk and a direct relationship between the length of the adjustment interval and call and market risk. This implies that as the adjustment interval lengthens, the amount of delinquency and default risk inherent in the mortgage design decreases, but the amount of call and market risk increases. And last, the volatility of the related interest rate series has direct relationship with the systematic risk of the mortgage. Mortgages that are designed with less volatile interest rate series have lower systematic risk.

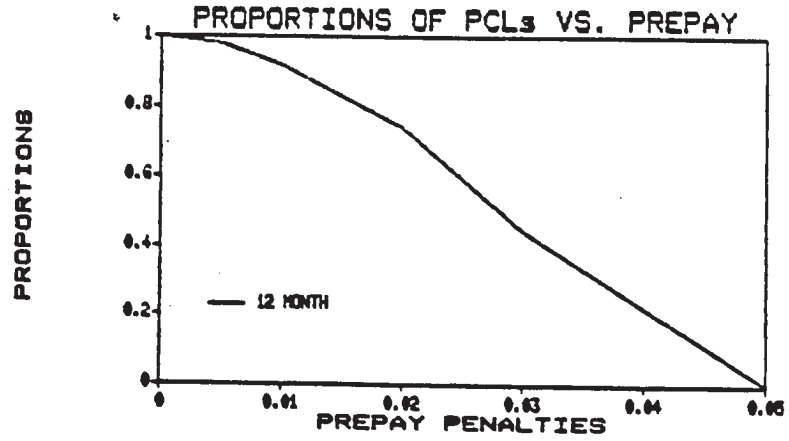
The Prepayment Penalty

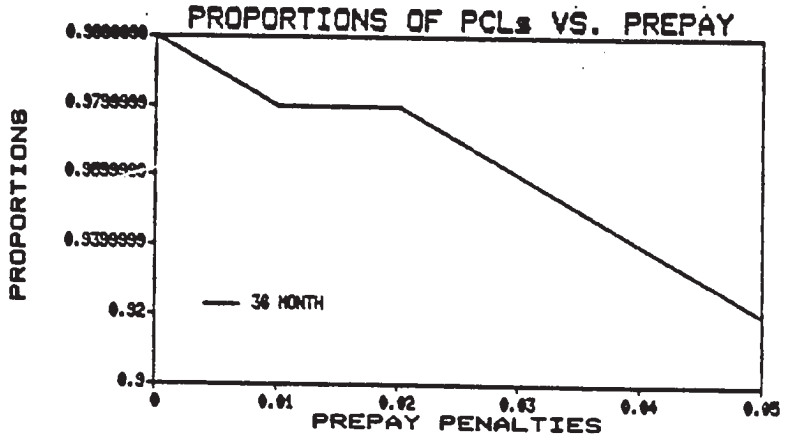
The prepayment penalty is inversely related to the both the size and probability of Potential Call Losses. In Chapters VI to IX, only the fixed rate mortgage design included a prepayment penalty. This reflects the current Federal Home Loan Bank Board regulations which do not allow prepayment penalties on adjustable mortgage loans. These regulations may be altered in the coming months so the impact of prepayment penalties

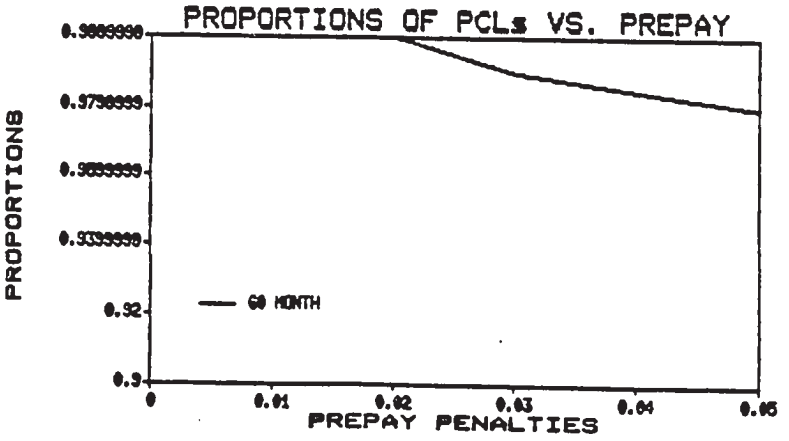
upon the Potential Call Losses of adjustable rate mortgages is also examined in this chapter. Theoretically, prepayment penalties reduce both the size and probability of lender losses associated with refinancing. The probability of a borrower refinancing is reduced because the size of the decline in interest rates necessary to cause a mortgage refinancing increases as the costs associated with refinancing increase. Prepayment penalties increase the cost of refinancing. They reduce the size of Potential Call Losses because the lender receives the remaining balance plus the prepayment penalty. The relationship between the prepayment penalty and the probability of Potential Call Losses is disclosed in Tables 6.1 and 8.1. In these tables the proportion of Potential Call Losses for the fixed rate mortgage with a three percent prepayment penalty is shown to be significantly less than the probability of a Potential Call Loss of any of the adjustable rate mortgages without prepayment penalties.

Table 10.1 reveals the relationship between the size of the prepayment penalty on adjustable rate mortgages and the probability of a Potential Call Loss. Notice that the impact of the prepayment penalty is much larger on mortgage designs with shorter adjustment intervals. A five percent prepayment penalty eliminates the occurrance of Potential Call Losses for one year adjustable rate mortgages and has little impact on the proability of Potential Call Losses for five year adjustable rate mortgages. The fixed rate mortgage with a three percent prepayment penalty has a lower probability of Potential Call Losses than the five year adjustables with a five percent prepayment penalty. This is

Table 10.1







Results are based on the upward biased disturbance term set and the adjustable payment mortgage.

explained by the interaction of the interest rate index, length of the adjustment interval and the initial coupon rate. The volatility of the three and five year indices is much greater than that of the fixed rate mortgage. Combining the volatility with the relatively long adjustment interval, results in a high sensitivity to Potential Call Losses. This sensitivity is further enhanced by the relationship of the initial contract rate to the range of possible contract rates. Since the initial rate is in the upper half of the interest rate range, there is an increase in the probability of the interest rate reaching a low enough value to trigger the Potential Call Loss. If the initial contract rate were in the lower half of the interest rate range there would be a decrease in the probability of interest rates reaching a low enough value to trigger a Potential Call Loss. The impact of the highly volatile interest rate index, relationship between the range of interest rate values and the initial contract rate, and the length of the adjustment interval dominate the influence of the prepayment penalty. This is not to say that the prepayment penalty has no impact. Table 10.3 reveals that the prepayment penalty does extend the termination month of the tested instruments.

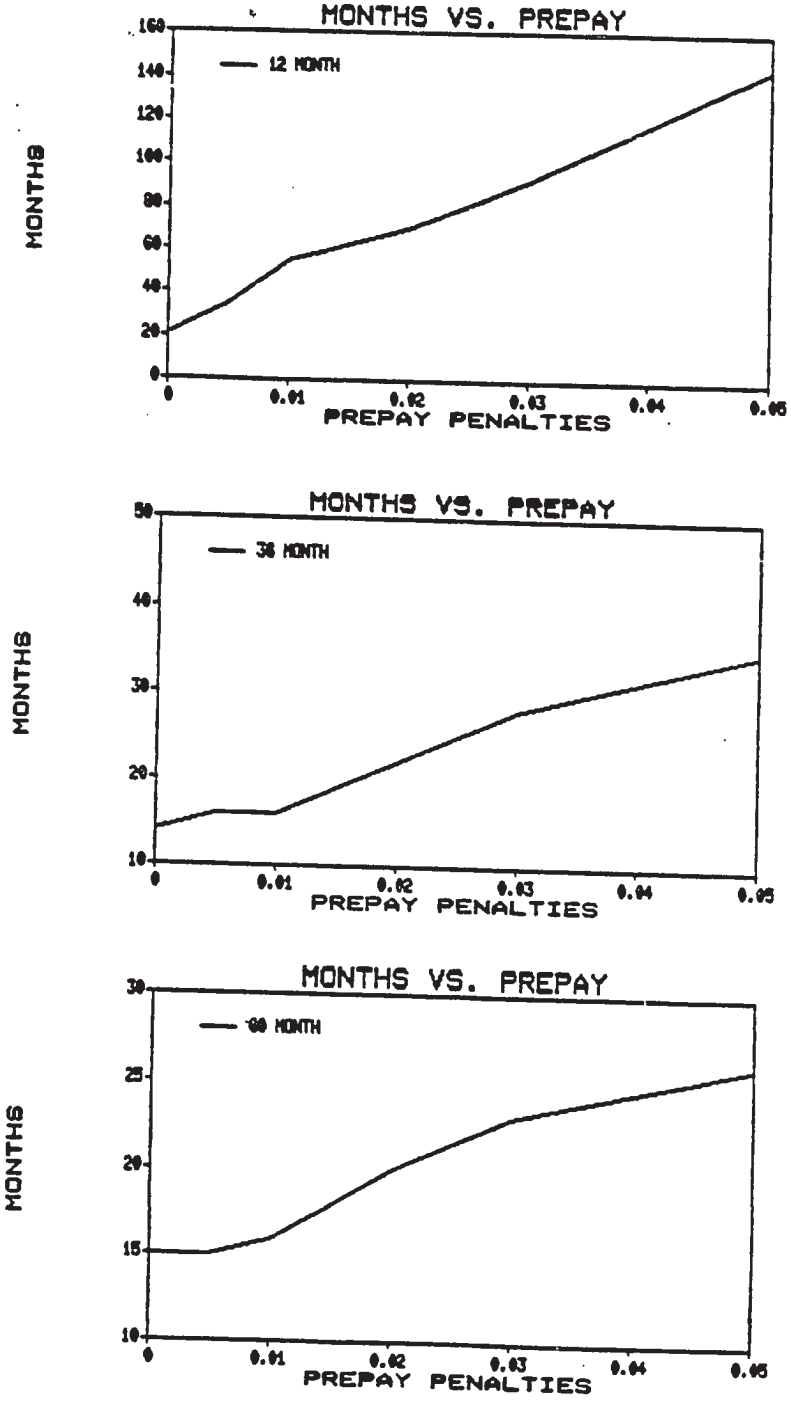
The size of Potential Call Losses is also influenced by the prepayment penalty. The Potential Call Loss calculation implies that as the prepayment penalty increases, the size of the Potential Call Loss should decrease. Table 10.2 reveals the impact of various prepayment penalties upon the size of Potential Call Losses. Notice that as the prepayment penalty increases, the size of the Potential Call Loss decreases. This result is consistent with expectations. Unfortunately,

the impact of the prepayment penalties is smaller than hoped. This reinforces the dominance of the volatility of the related interest rate series on the performance of the mortgage design. Further these results may be tainted by position of the initial contract rate in relation to the range of the related interest rate indices.

The results have indicated that the prepayment penalty has an impact on the probability and size of lender losses associated with refinancing. While the impact is not as great as desired, the prepayment penalty is a mortgage component that can be used to alter the systematic risk of a mortgage design.

The inability of mortgage designers to incorporate a prepayment penalty in the design of adjustable rate mortgages forces rationally priced mortgage designs to incorporate a premia for call risk into their initial contract rate. The size of the premia will be a function of the adjustment interval. Longer adjustment intervals require larger premia to compensate lenders for the level of call risk. Increases in the initial contract rate of a mortgage design will cause borrowers to qualify for smaller loans and reduce the demand for housing. This appears to be a contradiction to current government policy. To eliminate this contradiction, it is recommended that the adjustable mortgage loan regulations be ammended to allow mortgage designers to incorporate prepayment penalties in adjustable rate mortgage designs. This would allow mortgage designers to alter the systematic risk associated with refinancing, and reduce the need for a call premia to be added into the initial mortgage contract rate. The size of the prepayment penalty that

Table 10.2

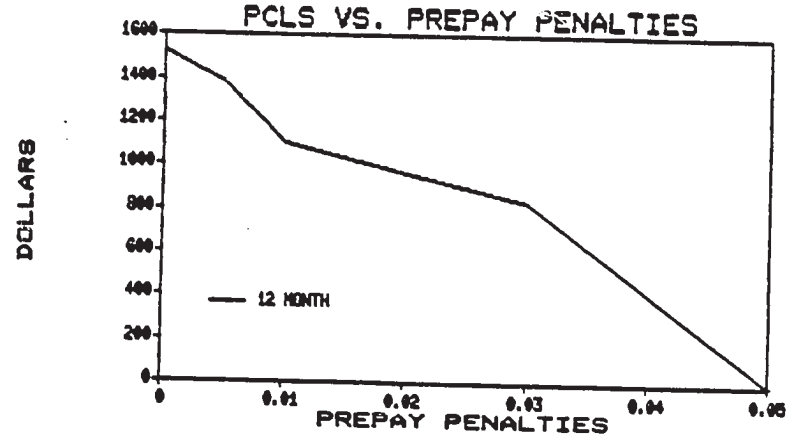


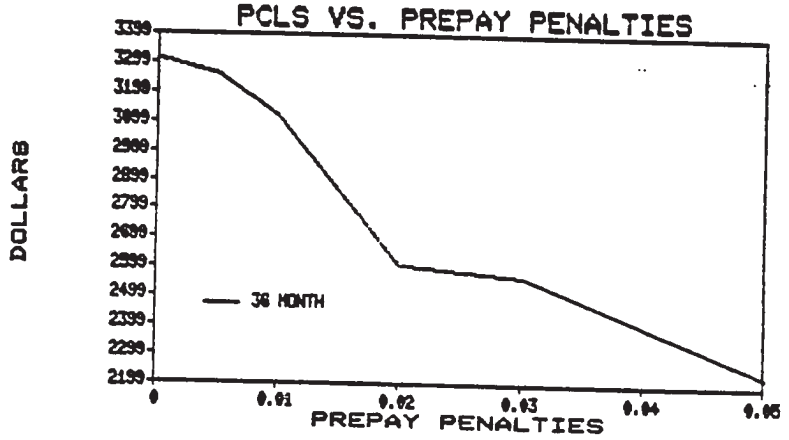
Results are based on the upward biased disturbance term set and the adjustable payment mortgage.

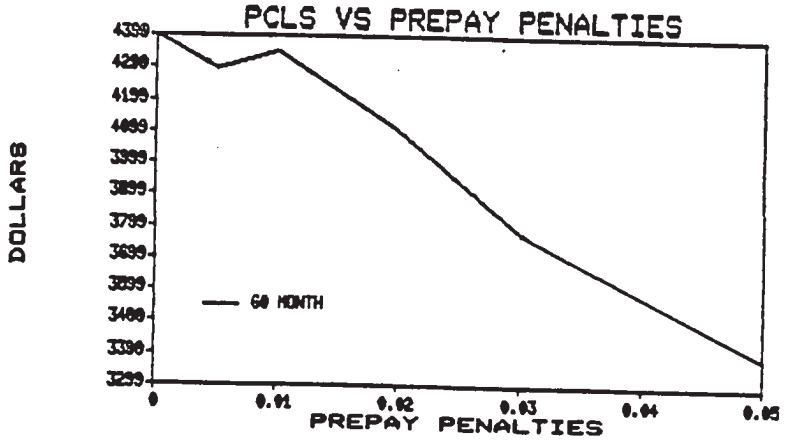
should be assigned to different mortgage designs is left for future research.

There is one potential drawback to the presence of a prepayment penalty. The proportion of Potential Default Losses increases when a prepayment penalty is present. This can be explained by looking at the triggering event of Potential Default Losses. In the option framework presented, the presence of a prepayment penalty increase the exercise price of the asset. This implies a greater probability for the option to be out of the money. Out of the money options equate to rational default. Therefore, under neutral disturbance terms, the proportion of Potential Default Losses is significantly higher for the fixed rate mortgage than for any other design. However, the size of the Potential Default Losses of the fixed rate mortgage are approximately twenty-five percent lower than those of the adjustable rate mortgages. This demostrates that the prepayment penalty increases the sensitivity of the mortgage to declines in the value of houses, but does not increase the size of the lender loss. The size of the Potential Default and Call Losses are similiar but their probabilities are very different. Call losses dominate default losses because they have a much higher proportion, seventy-five percent to seventeen percent. Mortgage designers should be willing to offset a portion of the benefits of a prepayment penalty with the default related costs.

Table 10.3







Results are based on the upward biased disturbance term set and the adjustable payment mortgage.

Monthly Payment Volatility

The volatility of the monthly payment is influenced by the adjustment mechanism, adjustment interval and payment cap. The volatility of the monthly payment has a direct impact on Potential Delinquency and Conditional Default. The triggering event for Potential Delinquency is an increase in the payment to income ratio to thirty-four percent or above. If a steady income pattern is assumed, delinquency can only be incurred by increases in the monthly payment. The adjustable payment mortgage is the only mortgage that has scheduled changes in the monthly payment. Other adjustable rate mortgages may incurr payment changes every five years due to large increases in the contract rate, but these changes are expected to be the exception and not the rule. This implies that the adjustable payment mortgage should have the largest exposure to delinquency risk. The results indicate this to be the case. The proportion of Potential Delinquency Losses and Conditional Defaults is not significantly different from zero for all of the adjustable term and balance loans under either neutral or upward biased disturbance terms. The proportions for the adjustable payment mortgages are significantly different from zero. The adjustable payment mortgages have the most volatile monthly payment pattern and are the only instruments to incur Potential Delinquency Losses. Adjustment mechanisms that increase payment volatility increase the probability of delinquency and delinquency related losses.

The adjustment interval of adjustable payment mortgages is

inversely related to payment volatility. The longer the adjustment interval the less volatile the monthly payment. The results indicate that the proportion of Potential Delinquency Losses decreases by approximately ninety percent as the interval increases from one to three years and by fifty percent as the interval is increased from three to five years. The decline in the proportion of Conditional Defaults between one and three years is approximately ninety percent and between three and five years is approximately one hundred percent. Longer adjustment intervals lead to significantly lower probabilities of delinquency and conditional default.

The size of Potential Delinquency Losses and Conditional Default Losses and Gains are also influenced by the adjustment interval of adjustable payment mortgages. The results indicate that the size of Potential Delinquency Losses decline by approximately twenty-eight percent as the adjustment interval increases form one to three years and by a slightly larger percentage as the interval increases from three to five years. The decline in Conditional Default Losses is even more pronounced. As the interval increases from one to three years the decline in Conditional Default Losses is approximately eighty-one percent. As the interval increases to five years the Conditional Default Losses disappear. Conditional Default Gains decline minimaly as the adjustment interval increases from one to three years and by forety-eight percent as the interval increases from three to five years. The results indicate that as the adjustment interval increases, causing a less volatile payment pattern, the probability of delinquency related

losses and the size of those losses declines.

The final mortgage provision to impact the volatility of the monthly payment is the seven and one half percent per period payment cap. By limiting the amount of the increase in the monthly payment, the payment cap reduces the volatility of the payments. The impact on the proportion of Potential Delinquency Losses is a decrease of ninety-six percent under upward biased disturbance terms. Under neutral disturbance terms the decrease ranges from ten percent for one year adjustable payment mortgages to thirty percent for five year adjustable payment mortgages. Conditional Defaults are eliminated by the seven and a half percent payment cap. The size of Potential Delinquency Losses decline by sixty-five percent when the payment cap is present. The seven and a half percent per period payment cap reduces the exposure of the lender to delinquency and delinquency related risk. The impact of the cap is most noticable on the one year adjustable payment mortgage.

Unfortunately the payment cap increases the proportion of Potential Default Losses by ninety percent for the one year adjustable payment mortgage when the disturbance terms have a neutral bias. The size of the losses is not affected by the payment cap. This result is caused by the combination of negative amortization and increased monthly payments. The increase in the proportion of Potential Default Losses for the one year mortgage represents a significant increase in risk exposure for the lender. It must be remembered that the Potential Default Loss triggering events represent the necessary conditions and may not be sufficient for a borrower to default due to the utility he assigns to remaining in the residence. It is felt that the cashflow impact of changes in the monthly

payment have a greater influence on borrower actions than the value of the mortgage as a call option in the short run. Therefore, payment caps are considered a necessary component of adjustable payment mortgages with one year adjustment intervals if borrowers and lenders are risk averse.

The Length of The Adjustment Interval

The adjustment interval has a direct impact on market, call, delinquency and default risks. The impact of changes in the adjustment interval upon delinquency risk were discussed above under Monthly Payment Volatility. The impact of increased adjustment intervals upon the probability of default paralels that of delinquency. The size of default losses does not change significantly as the interval increases from one to three to five years. It does decline by approximately twenty-five percent when the interval is increased to the life of the mortgage. Default losses are lower for mortgage designs with very long adjustment intervals. Small changes in the length of adjustment intervals do not impact the size of default losses but do decrease their probability.

The results indicate that the adjustment interval has a very limited impact on the proportion of mortgage calls but a significant impact on the size of the call losses. As the adjustment interval increases from one to three years the size of the call losses doubles. From three to five years the call losses increase by forty percent.

Longer adjustment intervals cause higher refinancing losses.

Potential Market Losses are directly related to the length of the adjustment interval. As the adjustment interval increases the size of the discount points required to sell the loan on the secondary markets increases. The increase in the size of Potential Market Losses from one to three year adjustment intervals is approximately three hundred percent. From three to five years the increase slows to seventy-six percent. The fixed rate mortgage Potential Market Losses are approximately three hundred percent of the five year interval adjustable rate mortgage losses. The length of the adjustment interval has a significant impact on the exposure of the mortgage to residual interest rate or market risk.

Summary

The results of this study have generated several conclusions about mortgage design and risk. Mortgage terms that decrease the volatility of the monthly payment decrease delinquency and delinquency related losses. Longer adjustment intervals increase market and call losses but decrease delinquency and default losses. Prepayment penalties reduce call losses. These findings indicate that lenders who are risk averse should structure the mortgage in a fashion that restricts changes in the monthly payment, allows the contract rate to change every one to three years, and includes prepayment penalties.

The results also indicate that all mortgage designs are sensitive to the pattern of income and house values. When income levels are

increasing, delinquency and conditional default represent minor risks. When income levels are not increasing delinquency and conditional default become important considerations in mortgage design. when house values are rising default is not as important a consideration in mortgage design as when house values are stable. Mortgage risks are impacted by the direction of change in the level of house values and income levels.

The volatility of interest rates appears to have a greater impact on the risk of a mortgage than the direction in which the rates are biased. The differences between the results of the biased and neutral disturbance terms for interest rate sensitive Potential Losses appear small in comparison to the change in the income and house value sensitve Potential Losses. This indicates that any assumptions made about the direction of interest rates used in the design process must include an estimation of the volatility of interest rates as well. A mortgage designer may predict the correct trend in interest rates but the mortgage may suffer an unexpected loss due to the volatility of interest rates. It should also be pointed out that all of the mortgages examined have an initial contract rate that is in the upper half of the range of interest rates. This may have contributed to the importance of the volatility of interest rates.

The purpose of this paper was to present a model that rationally compares the systematic risks of mortgage instruments and use this model in the comparison of a select group of mortgage provisions. This was accomplished and resulted in three conclusions. First mortgage designs should be allowed to carry a prepayment penalty. Second, payment

volatility should be controlled by payment caps, adjustment interval or adjustment mechanism. Third, longer adjustment interval increase interest rate sensitive risks but decrease income and house value risks. The findings indicate that mortgage provisions seldom impact one and only one form of risk and that tradeoffs between the terms of a mortgage, its initial contract rate and mortgage risks must be considered carefully.

Future Research

The model introduced in this study can be used in a variety of ways. Two of the more exciting possibilities are determination of equilibrium prepayment penalties for adjustable rate mortgages and the pricing of the various mortgage adjustment mechanisms, intervals and caps. The next generation of this model will include all of its current components and an additional one. The model will simulate the cashflow pattern of various mortgage designs and calculate their internal rate of return. Then the initial contract rate of the mortgages will be altered until their internal rates of return are not significantly different. The difference between the initial contract rates of any two designs will represent the minimum premium that a lender would have to charge in order to earn the same risk adjusted rate of return on the two mortgage designs. By comparing selected mortgage designs a mortgage provision pricing table may be developed. The same technology can be used to determine prepayment penalties and the size of caps.

The model of mortgage risks introduced in this paper has been used to estimate differences in mortgage risks associated with different mortgage provisions. Future uses of this model include but are not limited to mortgage pricing, finding the equilibrium size of mortgage caps and payments and testing the impact of new mortgage designs on mortgage risks.

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