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PRICING ADJUSTABLE RATE MORTGAGES

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ABSTRACT

This paper provides a framework for pricing adjustable rate mortgages and summarizes some evidence on the prices (additions to the coupon rate) necessary to cover expected losses from the binding of various interest rate caps and from mortgage default and foreclosure. Both interest rate and default risk are shown to be heavily influenced by the form of the mortgage instrument as well as the underlying drift and uncertainty in interest rates and house prices.

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Pricing Adjustable Rate Mortgages*

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Adjustable rate mortgages (ARMs) may seem to some to be the panacea of the thrift industry. With a direct matching of the repricing period on the ARMs and the maturity of deposits, interest rate risk disappears and the thrift is home free. Possibly managers can return to the old (but inflation adjusted) adage: borrow at 9, lend at 12 and be on the golf course by 3.

Unfortunately for the thrift manager, the world of ARMs is not so simple. Consumer acceptance may require teaser rates and interest rate or payment caps, which reintroduce some interest rate risk and add a dash of extra default risk for good measure. Numerous questions must be addressed. What repricing or adjustment period should be chosen, which caps and teasers should be offered, which index rate should be employed, and what margin over the costs of funds must be charged for the ARM to be profitable? We had better cancel that three o'clock tee time.

Investment in ARMs poses the dual problem of determining which ARM to offer to purchase (which adjustment period to offer, caps to utilize, initial charges to make, and index rate to employ) and how to price it (what full margin to charge). A rational thrift would solve this problem in reverse order. It would first calculate how a wide range of ARMs need to be priced in order to be profitable in a risk-adjusted expected value sense; then it would deduce which one or ones among this set households are likely to accept. This deduction, which I label the marketing decision, depends partly on one's competition (if a competitor is offering a specific ARM at a price below our

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thrift's estimate of a profitable price, then our thrift is unlikely to be able to market the ARM at its price) and partly on the tastes of household borrowers (many might not even consider a mortgage without a life-of-loan cap). The marketing decision will be solved by surveying the competition (and possibly potential borrowers) and by trial and error, i.e., letting households make their tastes known directly.

The marketing decision is not the topic of this paper. My topic is the pricing decision: how does a thrift calculate the margin necessary for profitability? I begin by laying out a general framework for determining the correct margin. Within this framework, the margin is seen to depend on a variety of costs and on expected income shortfalls caused by interest rate caps and possible foreclosures. I then examine the determinants of these shortfalls in detail and indicate the general magnitudes of the premia thrifts should charge for likely losses due to interest rate caps and foreclosure on differently structured ARMs.

I will not oversell my product; I am not able to say precisely what the appropriate margin for a given ARM should be today; there has not been either enough practical experience with ARMs or sufficient research on them to set margins with full confidence. Moreover, even if I could specify today's correct margin, I would not be able to specify tomorrow's because the determinants of the margin change over time. I will, however, indicate both the determinants and likely ranges of margins on different ARMs.

I. The Basics of ARM Pricing

A general framework is a necessary starting point for calculating ARM prices. This framework is also useful in identifying the advantages of thrifts relative to other lenders in financing housing. After developing the framework and briefly considering the relative advantages of thrifts, two components of ARM pricing, measurement of the cost of debt and choice of the index rate, are considered.

A. The General Framework

The basic question is at what minimum mortgage interest rate can a specific lender offer credit to households and still earn a market return on its equity? In the absence of taxes, the minimum interest rate must cover (1) the marginal expected cost of funds (an average of the cost of debt and equity finance) over the life of the mortgage, (2) expected losses due to default and interest rate caps, (3) servicing costs and (4) operating/packaging costs. To illustrate the latter, a depository institution must pay the costs of collecting deposits, including having branches, paying employees, etc.; Freddie Mac, on the other hand, pays the cost of marketing its participation certificates.

When taxes are included, the analysis becomes more complicated. In order to see things clearly, a few equations are helpful. The expected after-tax profit -- return to equity -- from a dollar investment in mortgages (π) can be expressed as

$$\pi = (1-\tau)[\text{mor} - \text{for} - \text{cap} - \gamma\ \text{debt} - \text{ser} - \text{oper}], \qquad (1)$$

where τ is the relevant business tax rate, mor is the promised return from mortgage investment, for is expected losses due to foreclosure, cap is expected losses due to interest rate caps, γ is the fraction of the dollar investment (say 0.95) that is debt-financed (deposits for thrifts, PCs for Freddie Mac), debt is the cost of that debt, ser is servicing costs and oper is operating or packaging costs. All variables are fractions per dollar of mortgage investment, and all refer to present-value annual-equivalents over the expected life of the mortgage investment.

The minimum mortgage yield acceptable to an investor, mor_m, is that at which the institution would expect to earn an after-tax return on its equity investment equal to the return required by investors, equ. Because there are $1/(1-\gamma)$, say 20, dollars of mortgage investment for every dollar of equity,

$$\pi/(1-\gamma) = equ, \tag{2}$$

when $mor = mor_m$. We solve for mor_m by equating (1) and (2):

$$mor_m = for + cap + \gamma\ debt + \frac{(1-\gamma)equ}{1-\tau} + ser + oper. \tag{3}$$

The required <u>margin</u> on mortgage investments can be expressed as the difference between the mortgage rate and the cost of debt:

$$mor_m - debt = for + cap + ser + oper + \frac{(1-\gamma)[equ - (1-\tau)debt]}{1-\tau}. \tag{4}$$

That is, the margin must cover the difference between promised and expected mortgage returns (for + cap), expenses of investing in mortgages (ser + oper), and a little extra because the after-tax required return on equity exceeds the after-tax cost of debt. Differences in margins across industries could exist owing to tax and regulatory advantages (differences in τ, γ and debt) or to technological or managerial advantages (differences in ser, oper and possibly def); by assumption, the required returns on equity are equal for all institutions (the γ's are assumed to be those which make the equity investment equally risky for all industries) and all investors presumably suffer equal losses from identical rate caps. The margin will vary across firms within an industry because of differences in managerial skills (reflected in differences in ser, oper and for).

Given unlimited access to funds, the industry with the lowest margin will eventually drive all other industries out of the home mortgage business. If access is limited (or diseconomies of scale exist), such as was the case with thrifts in the era of deposit rate ceilings, then the margin of firms in the next "lowest cost" industry will determine the market home mortgage rate, etc., until the demand for mortgage credit is satisfied (see Hendershott and Villani, 1980, pp. 64-69). Institutions that can supply credit at a rate below the market equilibrium rate will earn excess profits; institutions that cannot supply credit at the market equilibrium rate will not survive.

Historically, mortgage investment has been predominately undertaken by the thrifts and Fannie Mae (sometimes labeled the world's largest savings and loan). And for good reason. Owing to the Treasury's implicit (explicit?) guarantee of Fannie Mae's debt and the inexpensive deposit insurance FSLIC provides thrifts, Fannie Mae and the thrifts have been able to borrow short and lend long at low cost. (Maturity intermediation is profitable, in the absence of a continuing upward trend in interest rates, because short rates are generally less than long rates -- 3-month bill rates have averaged nearly a percentage point less than long-term Treasury rates over the past 15 years.) In terms of equation (3), thrifts and Fannie Mae have had far lower debt costs and higher loan-to-value ratios than purely private firms have had (no institutions without deposit insurance or government guarantees have engaged in significant maturity intermediation).

Thrifts also have the Section 593 bad debt allowance (although they won't under many tax reform proposals) which lowers their effective tax rate based upon (large) minimum investment in mortgages. When "normal" profits exist, this allows thrift to lend at a quarter to half percentage point below the market rate and still make money (Hendershott and Villani, 1981). To the extent that Fannie Mae and the thrifts have passed through their advantages to households, the cost of housing finance has been below market. On the other hand, raising funds through the deposit-branch system may be inefficient relative to the passthrough security mechanism (the thrift industry may have relatively high operating expenses). Also, builders can utilize installment sale accounting with their builder bonds and thus can afford to engage in builder buy downs.

B. Measurement of the Cost of Debt and Choice of Index Rate

Three of the six variables determining the minimum acceptable mortgage rate in equation (3) are likely to vary significantly across ARM types: the cost of debt and expected losses from default and from the existence of rate caps. The cost of debt is analyzed here, as is a companion issue, the choice of the index rate; the expected loss components are considered in some detail later in the paper.

The relevant cost of debt to employ in ARM pricing is the marginal expected cost of debt financing until the ARM reprices. Note the adjectives marginal and expected. Both indicate that the average cost of funds over the most recent accounting period is not the correct measure of the debt cost. The measure must be current -- the cost of raising funds today -- and must be forward looking -- the expected cost until repricing occurs.

Application of this rule is simple in some cases. Say that a thrift raises its funds with six-month deposits and is pricing a six-month ARM. The correct cost of debt is today's cost of raising funds, today's six-month deposit rate. (This is not precisely correct; a slightly shorter term debt rate is appropriate because the ARM amortizes slightly. On the other hand, if the ARM has rate caps, a slightly longer term debt rate is relevant because the ARM will not always fully reprice in six months.[1]) Similarly, a thrift financing a one-year ARM with one-year deposits would use today's one-year deposit rate as the base debt rate in computation of today's one-year ARM rate. But what about a thrift that finances one-year ARMs with six-month deposits? Here the expected debt cost is an average of today's deposit rate and that which the thrift expects to exist six months from now.

How might a thrift form expectations of this rate? Under the assumptions that deposit rates will move with Treasury rates of the same maturity and longer term Treasury rates are averages of current and expected future short-term Treasury rates, the expected change in the six-month deposit rate can be inferred from the relationship between the current yields on one-year and six-month Treasuries. To illustrate, if the current one-year Treasury rate is 12¼ percent and the current six-month rate is 12 percent, then the market's expectation of the six-month rate six months from now is 12½

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[1]In the extreme, a fixed-rate mortgage (an ARM with an rate-increase cap of zero?) may be unable to reprice for up to 30 years. Thus an average of expected six-month debt costs over a long future period is appropriate.

percent.[2] Because the six-month deposit rate is expected to be one-half percentage point higher in six months, the base debt rate for setting the one-year ARM coupon would be today's six-month deposit rate plus one-quarter percentage point. That is,

$$\begin{matrix}\text{one year}\\ \text{base rate}\end{matrix} = \begin{matrix}\text{six-month}\\ \text{deposit rate}\end{matrix} + \tfrac{1}{2}\left(\begin{matrix}\text{one-year}\\ \text{Treasury}\end{matrix} - \begin{matrix}\text{six-month}\\ \text{Treasury}\end{matrix}\right).$$

With a current six-month deposit rate of 11½ percent, the base rate is 11 3/4 percent.

This rule can be stated another way: the base rate for an ARM of given repricing period should be the Treasury rate of that maturity plus the difference between the deposit rate at which funds are being raised and the Treasury rate of the same maturity as that deposit rate. In the previous example, the base rate is .1225 + (.115 - .12) = .1175. More generally, if we assume an ARM is financed with deposits of a variety of maturities, we can write:

$$\begin{matrix}\text{Base rate ARM}\\ \text{with repricing}\\ \text{period of n}\end{matrix} = \begin{matrix}\text{Treasury}\\ \text{rate with}\\ \text{maturity n}\end{matrix} + \sum_i w_i \left(\begin{matrix}\text{deposit}\\ \text{rate with}\\ \text{maturity i}\end{matrix} - \begin{matrix}\text{Treasury}\\ \text{rate with}\\ \text{maturity i}\end{matrix}\right),$$

where w_i is the proportion of the ARM investment financed with deposits of maturity i. To illustrate, if a six-month ARM were financed with equal proportions of one, six and 12 month deposits, then the base rate would be the current six-month Treasury rate plus an average of the differences between the current rates on one, six and 12 month deposits and Treasuries.

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[2] If investor's are earning a risk premium for committing funds for a year instead of six months, then the expected six-month rate six-months in the future is less than 12½ percent. Nonetheless, thrifts should treat it as 12½ percent because they should earn this risk premium for borrowing six-month money and lending for a year.

From the above analysis, the choice of the appropriate ARM index rate is straight-forward: the Treasury rate with the same maturity as the repricing period. With this index, an individual thrift will have the wherewithal to compete for deposits in the future should interest rates rise. Moreover, borrowers will not have an incentive to switch to other lenders should interest rates decline.

The industry's aggregate cost of funds index, a popular alternative, has a number of disadvantages. First, it is backward looking; its movement does not reflect changes in the current marginal cost of debt funds but movements in the average cost from some prior period (not that prior given how short the average maturity of thrift liabilities has become). Second, the cost of funds index reflects behavior of the industry, not the individual thrift. If, for example, other institutions cease attracting deposits at above market rates or if their relatively high cost longer term deposits roll over at lower rates, then the cost of funds index, and thus rates on repricing ARMs, will decline, even though the level of interest rates, and thus this thrift's cost of funds, has not changed since the ARMs last repriced. The backward-looking nature of the cost of funds index and its sensitivity to the behavior of thrifts, rather than the general level of interest rates, probably explains the preference of the secondary market for ARMs indexed to Treasury rates.

II. Expected Losses from Interest Rate Caps

Risk-adjusted expected losses from interest rate caps depend on the likelihood that interest rates will rise sufficiently for the caps to bind and the aversion lenders have to the caps binding while the cost of funds rises unchecked. This problem is addressed in two ways. First, I indicate how an option pricing model could be used with current market data to determine the extra margin to be charged for rate caps. Second, I examine interest-rate data over the 1970-84 period to deduce what extra margins were necessary, ex post, for lenders to avoid losses on capped ARMs relative to uncapped ARMs.

A. The Use of Option Pricing Models

Expected losses from interest rate caps depend on the expected "drift" and "volatility" of interest rates. The higher is the drift, the more likely are rates to rise sufficiently to cause caps to bind. Similarly, the greater the volatility, the more likely are rates to blip upward sufficiently to cause the caps to come into play. Thus, margins on capped ARMs should vary over time as the expected drift and volatility of rates vary.

Also relevant to the compensation for rate caps is risk aversion. Given the existence of rates caps (and the effective early withdrawal option on longer term deposits), a lender cannot match the effective maturities of its assets and liabilities. A one-month ARM with a life of loan cap will have a one-month effective maturity if interest rates are relatively stable but could end up with a much greater effective maturity should interest rates rise sharply and stay at a much higher average level. A risk-averse lender should charge for this risk or for any hedging actions taken to limit it.

A single piece of market information, available daily in the Wall Street Journal, reflects both the expected drift in interest rates and current market risk aversion -- the term structure of interest rates. When the term structure is upward sloping, whether due to an expected upward drift in interest rates or to aversion to committing funds longer term, lenders should charge more for rate caps. Similarly, if recent interest rate behavior reflects greater interest rate volatility than was previously the case, a higher margin should be charged. And correct margins can be quite sensitive to these parameters.

Table 1 contains the values of the extra premium required for adding a five percent life of loan cap to a pure one-month ARM contract under different term structure and rate volatility assumptions. These premia were computed using an option pricing model (see Buser, Hendershott and Sanders, 1984). When the yield curve is mildly upward sloping (the spread between long-term and three-month Treasury rates is one percentage point) and rates are expected to have average volatility, the premium for this cap is about ten basis points. With a downward sloping yield curve or low rate volatility, the fair margin approaches zero. However, a steeply upward sloping yield curve (long-term less three-month Treasury spread of 2 3/4 percentage points) or high expected rate volatility raises the premium to a quarter percentage point, and the combination together puts the premium over half a percentage point.

Per period rate adjustment caps and initial period teaser rates are also common in ARM contracts. Unfortunately, researchers have not yet solved the problems inherent in valuing per period adjustment caps with option pricing models, although the values of these caps are surely related to interest rate expectations and volatility in the same way that the value of the life of loan cap is.[3]

[3] Asay (1984) has simulated per-adjustment period cap values based upon different term-structure and rate-volatility assumptions.

Table 1:

Option Pricing Model Values (in basis points) of 5 Percent Life of Loan Cap on a One-Month ARM
(no per adjustment caps)

Slope of Term Structure / Rate Volatility	Downward (-125)	Normal (100)	Steeply Upward (275)
low	0	0	15
average	0	10	35
high	10	25	60

B. Implications of 1970-84 Interest Rate Behavior

To shed some light on the values of different interest rate caps, alone and in combination, Hendershott and Shilling (1984) analyzed how much higher the coupon rates on hypothetical ARMs with various caps issued during the 1970-76 period would have had to have been in order for lenders to earn the same return as would have been earned on uncapped ARMs with the same repricing period. (The calculations assume a 7½ year holding period and include a market value adjustment at the end of the period if caps were then binding.) The emphasis is on establishment of relationships among cap values that hold for mortgages originated in all years. (Mortgage default was not considered -- private mortgage insurance was implicitly assumed to be sufficiently comprehensive to reduce default risk to the lender to zero.)

The computed margins depend, of course, on the actual behavior of interest rates in the years following the assumed origination date. Rates oscillated around 7 percent in the 1970-77 period, rose sharply during 1978 and 1979, and then oscillated around 12 percent in the 1980-mid1984 period. Thus required ex post margins rose throughout the 1970-76 period. Hendershott and Shilling present computations for: one-year undiscounted ARMs, one-year discounted (two percent teaser) ARMs, and three- and five-year ARMs. Only the results for one-year ARMs are summarized below.

One-Year Undiscounted ARMs

Table 2 presents the basic results for various interest rate caps with and without interest rate floors on one-year ARMs originated in the years 1970 through 1976. I first discuss the capped only values and then turn to the floors. The values of one and two percent caps per annual adjustment are listed in the first two columns of Table 2. The average for the 1970-76 span is given at the bottom of the table. The tight one percent cap is worth nearly a full percentage point on average; the two percent cap is worth only a quarter as much. This 4 to 1 ratio holds not only on average but also, roughly, for mortgages originated in each year.

The values in the next three columns are for a five point life of loan cap, both by itself and in combination with the annual adjustment caps. The five percent life of loan cap alone has about as much value, on average, as the two percent per year cap, 28 basis points, but the range of the value of the life cap is much wider. For mortgages originated in many years, the life of loan cap will not bind at all; for other years, it will bind over much of the period. When appended to the one point per adjustment cap, the five point life of loan cap adds negligible value; unless interest rates were to rise sharply and stay there for an extended period, the per adjustment cap binds prior to the life of loan cap. When appended to the looser two point annual cap, the life of loan cap adds about half of its value by itself, the two points per year and five point life of loan caps together are worth 40 basis points, on average. The half-of-its-value-alone rule for adding the 5 percent life of loan cap to the two point annual cap holds, roughly, for mortgages originated in all years, not just on average.

Comparison of the average values of interest rate caps when used in conjunction with symmetric floors (the data in parentheses) with the values calculated on ARMs without floors suggests that the introduction of a rate floor lowers the required margin anywhere from 0 to 15 basis points. The greatest effect, as one would expect, is for the one percent adjustment cap with a five percent life of loan cap, although by itself the annual adjustment cap yields similar results. The five percent life of loan floor never seems to matter. Because borrowers will tend to prepay their mortgages if rates fall

Table 2

Additional Margins Needed to Compensate for Various Interest Rate Caps on 1-Year Default-Free ARMs, 1970-1976
(Percentage Points)

Year	No Life of Loan Cap, Annual Cap: 1%	No Life of Loan Cap, Annual Cap: 2%	5% Life of Loan Cap, Annual Cap: No Cap	5% Life of Loan Cap, Annual Cap: 1%	5% Life of Loan Cap, Annual Cap: 2%
1970	0.34 (-.10)	0.06 (-.02)	0	0.34 (-.10)	0.06 (-.02)
1971	0.46 (0.40)	0.10	0	0.46 (0.40)	0.10
1972	0.74 (0.68)	0.16	0.06	0.74 (0.68)	0.18
1973	0.82 (0.66)	0.20 (0.18)	0.14	0.82 (0.66)	0.24 (0.22)
1974	1.38 (1.12)	0.38	0.30	1.40 (1.14)	0.50 (0.48)
1975	1.54 (1.44)	0.42 (0.40)	0.72	1.62 (1.52)	0.82
1976	1.64 (1.62)	0.46 (0.40)	0.80	1.66 (1.62)	0.90
AVERAGE	0.98 (0.83)	0.26 (0.21)	0.28	1.00 (0.85)	0.40 (0.38)

sufficiently below the minimum rate floor, the true values of the various rate caps with floors are somewhere between the capped-only values and the capped-with-floors values.

One-Year Discounted ARMs

Table 3 presents the same general calculations of the values of caps on one-year ARMs but now for ARMs issued with a two percentage point annual teaser. The tight one percentage point annual cap costs 160 basis points on average. This includes 30 basis points needed over an eight year mortgage life to recoup the 2 percent initial year discount (the 7 percent life of loan cap on a mortgage issued in 1970 costs 30 basis points and we know from Table 2 that this cap never binds) and 130 basis points more for the cap. The 130 far exceeds the 98 basis point cost of the same cap on an undiscounted one-year ARM. This illustrates the general point that all rate caps are more likely to bind when a teaser rate is used and thus the margins charged must be higher. When a five percentage point life of loan cap is added to the one percent per adjustment cap, the margin value rises, on average, by only 10 basis points.

When the annual adjustment is two percentage points, the cap on the two percent teaser ARM is worth 72 to 116 basis points, the 72 being associated with no life of loan cap and the 116 with the five point cap. Results for a two point annual cap and a six point life of loan cap are also shown. Comparing Tables 2 and 3, a one percent annual adjustment cap and five percent life of loan cap on an undiscounted one-year ARM seems to have about the same percentage point value as a two percent annual adjustment and six percent life of loan cap on a two percent discounted one-year ARM. This is another result that seems to hold for most every year, not just on average.

Table 3

Additional Margins Needed to Compensate for Various Interest Rate Caps on 1-Year Default-Free ARMs When a 2% Discount Is Employed (Percentage Points)

	1% Per Adjustment Period Cap Life of Loan Cap		2% Per Adjustment Period Cap Life of Loan Cap			Life of Loan Cap Only	
Year	No Cap	5%	No Cap	5%	6%	5%	7%
1970	0.64 (0.58)	0.64 (0.58)	0.38	0.38	0.38	0.30	0.30
1971	1.20 (1.16)	1.20 (1.16)	0.50	0.56	0.50	0.44	0.32
1972	1.74 (1.72)	1.76 (1.74)	0.90	1.14	1.00	0.64	0.38
1973	1.40 (1.34)	1.48 (1.42)	0.68	0.94	0.80	0.64	0.46
1974	1.66 (1.58)	1.78 (1.72)	0.70	1.20	0.94	1.10	0.58
1975	1.92 (1.90)	2.24	0.78 (0.74)	1.80	1.42	1.76	1.00
1976	2.62 (2.60)	2.76	1.04 (0.90)	2.08	1.68	1.96	1.14
AVERAGE	1.60 (1.55)	1.70 (1.66)	0.72 (0.69)	1.16	0.96	1.00	0.60

The next two columns in Table 3 contain calculations for life of loan caps only of 5 and 7 percent. The 5 percent life of loan cap on a two percent discounted one-year ARM seems to be worth about the same percentage point as it does in conjunction with the one-percent annual adjustment cap on the undiscounted one-year ARM.

Finally, Table 3 shows the combined effects of various interest rate caps and floors. In general, the floors have negligible value because rates would have to fall below the already discounted original coupon rate before they would be expected to bind. In any event, only the tight annual adjustment caps appear to have value; the one percent interest rate floor is worth about 5 basis points (see Tables 2 and 3).

III. Expected Losses from Foreclosures

Mortgage default depends critically on the downpayment of the borrower and the scheduled amortization rate of the loan. The greater are these, the less likely is default. But default also depends on whether an ARM is used rather than a FRM and just what type of ARM is employed. How differences in the type of mortgage affect the net (of foreclosure losses) returns to mortgage lenders is crucial to the pricing of ARMs. I begin with presentation of an "intuitive" model of how and why financing arrangements affect mortgage default and then provide some illustrative historical calculations on the movement of the determinants of default for different mortgages originated in 1977. I conclude with a discussion of lender losses stemming from foreclosures. Throughout, the term default denotes borrower behavior that will lead to foreclosure.

A. Financing Arrangements and Mortgage Default

The owner of a house financed by mortgage debt will default on that debt if the gains from doing so exceed the perceived costs. The gains are the value of the mortgage debt wiped off the books and the free rent that can be obtained between the time of default and actual foreclosure. The losses are the house given up and "default costs": the dollar costs of moving, losses of attachable assets and credit rating, and the psychological or moral cost of defaulting. The dollar costs include moving one's family and belongings and purchasing another house (if possible) or foregoing the advantages of ownership. The default condition can be expressted algebraically as: default if

$$H < M - C, \tag{5}$$

where H is the value of the house given up, M is the market value of the mortgage and C is net default costs (gross costs less the free rent gained).

While the default condition is similar in principle whether or not households have to move, default costs are greatly reduced if the household has to move in the absence of default. First, the emotional and dollar costs of moving do not act as a deterrent to default. Second, the household must sell the house if it chooses not to default. This negative cost of defaulting acts as an incentive to default. Third, many households are forced to move because of a personal tragedy -- death of a member, severe illness, divorce, or prolonged unemployment. At such moments the normal moral aversion to default is likely weakened: the world is being cruel and it seems only fair that others share the burden of the household's tragedy. For households that have to move, the default condition is

$$H < M - C_m, \tag{6}$$

where net default costs of such households, C_m, are much less than those of nonmovers, C.

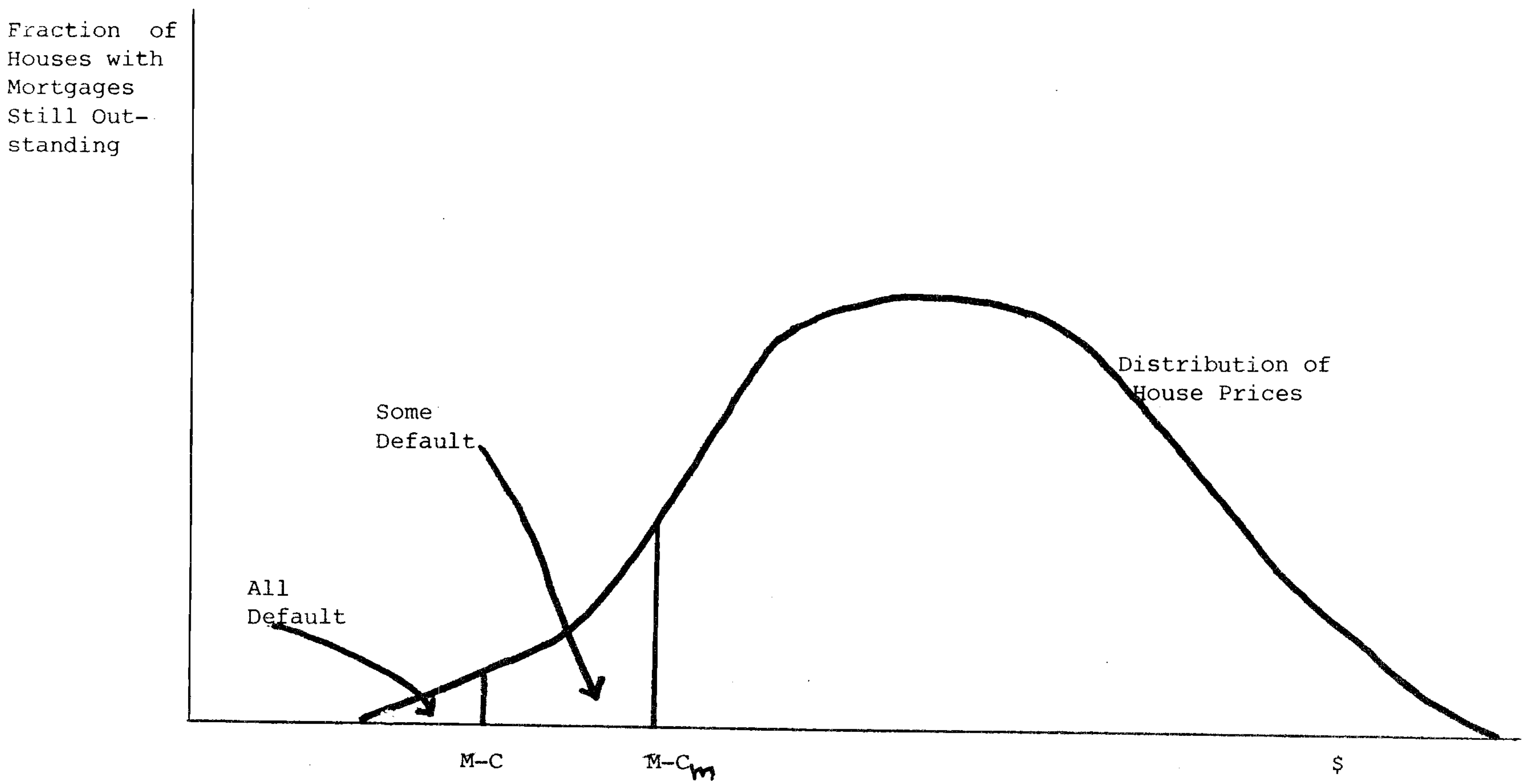
From (5) and (6), default is clearly quite dependent on the uncertain time path of individual house values. Other things being equal, defaults are more likely to occur the more the value of a property declines. (Of course, higher loan-to-value and slower amortizing loans will experience greater default.) Default is also household specific because the default costs will vary from household to household, depending on their moral aversion to default as well as local laws regarding recourse to assets.

Consider a pool of identical loans made on initially equal valued houses. At some future date, there will be a distribution of the values of the houses underlying the mortgages remaining in the pool. This distribution will depend on both the process governing the evolution of house prices over time (the mean house price inflation rate and the dispersion around it) and the manner in which mortgages have been deleted from the pool (defaulted on) in earlier periods. Figure 1 plots this distribution of house values at a date a number of years after origination of the mortgages. The horizontal axis is dollar values, and the vertical axis is the fraction of houses whose mortgages remain in the pool that have a particular value. M is the current value of the outstanding mortgages. The fraction of houses of value $H \leq M - C$ will all default. In addition, households who have house values between $M - C_m$ and $M - C$ and have to move will default. That is, a fraction of households with house values in this range, households that might be considered "potential defaulters," will default.[4] Few households (largely those with low aversion to

[4]For evidence that the household's net equity in the house is an important determinant of default, see Foster and Van Order (1984).

Figure 1

House Prices, Default Costs, Mortgage Value and Default



default) have house values less than M - C; most defaults come from the potential defaulters. Thus default has been characterized as the intersection of two bad events: a relatively sharp decline in house price and a tragedy that forces a move.

An important question is when might default rates on adjustable-rate (ARM) and fixed-rate (FRM) mortgages differ? The answer is when interest rates rise. Increases in rates, holding C, C_m and the house price distribution constant, will lower defaults on FRMs and raise them on uncapped ARMs. Because of this, mortgage insurers can diversify away a substantial part of interest-rate induced default risk by insuring the appropriate proportions of fixed and adjustable rate mortgages.

Consider FRMs first. Intuitively, households that have below-market rate mortgages are less willing to give them up (default) than are other households. In terms of Figure 1, the increase in interest rates lowers the market value of the fixed-rate mortgage, shifting M - C to the left. The M - C_m line will also shift to the left if the mortgage is assumable, i.e., if a household that has to move can capture the decline in market value of its debt via a higher house price upon sale. If the mortgage is not assumable, the reduction in defaults arises because a number of households who would have defaulted in the absence of the increase in interest rates will now default only if they have to move.

With an uncapped short-term ARM, M does not decline in response to an increase in interest rates. Moreover, increases in ARM rates will "force" movement by households that cannot absorb payment shock, lowering default costs and raising defaults. In terms of the figure, a greater portion of the households with house values between M - C and M - C_m will have to move and thus will default.

Of course there are numerous types of ARMs, and each will be affected differently by increases in interest rates. Five-year ARMs will be less likely to default than one-year ARMs; the market value of the five-year ARM will decline (although not as much as would an FRM), and payment shock will not hit for five years (at which time inflation will likely have raised incomes and shifted the house distribution to the right and amortization will have lowered M). ARMs with rate caps will be less likely to default than otherwise identical ARMs without caps for the same reasons: M will decline somewhat and payment shock will be less. Teaser ARMs -- those with built-in interest rate hikes -- will be more likely to default owing to greater payment shock.

What about declines in interest rates? In general, their differential impact on the market values of FRMs and ARMs and thus on default probabilities is far less than the differential impact of increases in rates. Declines in rates will tend to raise the market value of outstanding FRMs, thus increasing the likelihood of default (of H falling below the higher M - C), but the increase in value and tendency to greater default is limited. Households do not have to default in order to avoid large increases in the market value of their debt; they can, and generally will, refinance their loans at the lower market rates.

B. Some Calculations for Mortgages Originated in Early 1977

A follow up question is: do interest rates ever rise by enough to reduce defaults on FRMs noticeably or to increase defaults on ARMs markedly? The former would only occur in response to significant declines in the market value of FRMs and the latter to significant increases in payment/income ratios for ARM borrowers. To shed some light on this issue, mortgage market values and payment/income ratios have been calculated for the 1977-84 period for a 30 year, fixed-rate loan carrying the early 1977 8.76 percent coupon and an uncapped one-year ARM with a coupon of 7.06 percent that adjusts annually by the change in the one-year Treasury rate (which was 5.56 percent in early 1977). The market value of the uncapped ARM is set equal to its book value (initially $100,000); the market value of the FRM is computed by discounting the mortgage cash flows by the current long-term mortgage coupon rate, assuming a prepayment span that tends to decline as the mortgage ages but rise as the difference between the market coupon rate and the 8.76 coupon increases. The payment/income ratios assume that households had initial incomes to support four times the initial mortgage payments and that income grows at 6 percent per year (at the end of 7 years, incomes have risen by 50 percent).

The top panel of Table 4 contains the interest rates: the yield on the one-year ARM (the one-year Treasury rate plus 1.5 percentage points) and the coupon rate on conventional long-term fixed-rate loans. The second and third panels contain the market values and payment/income ratios for these mortgages and for a one-year ARM with a 7½ percent per year payment cap. The precipitous decline in the value of a fixed-rate mortgage originated in 1977 between then and 1982 is of no surprise to savings and loans. This one-third decline in value (less than $4,000 was due to amortization) was why most savings and loans (including FNMA) were substantially "underwater". Similarly, the failure of the market value of the pure ARM to decline beyond normal amortization is no surprise; this is the glory of ARMs and explains why many savings and loans have been struggling to restructure their balance sheets toward ARMs.

From a default perspective, however, ARMs are not so attractive. First, the low market value of the FRM means that households are unlikely to give it up by defaulting (H - M is large). Second, the payment-to-income ratios

Table 4: Market Values and Payment/Income Ratios

	First Half of							
Rates	1977	1978	1979	1980	1981	1982	1983	1984
One-Year ARM	7.06	9.05	11.62	13.61	16.07	15.56	10.52	12.29
Long-Term FRM	8.76	9.10	10.26	10.75	13.91	15.27	12.63	12.45
Market Values								
One-Year ARM	100.0	99.0	98.3	97.8	97.4	97.1	96.8	95.8
Long-Term FRM	100.0	96.7	88.7	85.1	69.3	63.6	75.8	76.7
One-Year ARM with 7½% Payment Cap	100.0	99.0	99.4	101.6	105.5	111.7	117.5	117.5
Payment/Income Ratios								
One-Year ARM	.25	.283	.329	.357	.392	.359	.243	.259
Long-Term FRM	.25	.236	.222	.210	.198	.187	.176	.166
One-Year ARM with 7½% Payment Cap	.25	.254	.257	.261	.264	.268	.272	.276

suggest significantly greater default on ARMs. For fixed-rate mortgages, the ratio falls from the initial one-quarter to one-fifth in the fourth year and one-sixth in the seventh. In spite of rising income, the ratio rises by over 50 percent -- from one-quarter to two-fifths -- for the ARM by the fourth year and then declines to about the original one-quarter by the seventh year. Truly enormous declines in house prices are required to create negative equity for households with the fixed-rate mortgage: 10 percent a year for the first four years would be insufficient. In contrast, 2 percent declines would be sufficient to induce households with pure ARMs to default if they could not handle the payments and many households would, indeed, find a fifty percent increase in their payments difficult to handle.

ARMs with interest rate caps are a compromise between these extremes. The decline in market value would be less than that of the FRM but more than that of the pure ARM to the extent that the caps bind (or threaten to bind), and the payment/income ratio would rise less than that of the pure ARM but more than that of the FRM. Thus rate caps reduce the likelihood of default. The impact of payment caps is uncertain. Payment caps do cushion the rise in the payment-to-income ratio during a period like 1977-84 (see Table 4); the ratio is between 26 and 27 percent in years 4 through 6, far less than the 35 to 40 percent ratio with an uncapped ARM. Thus households will be far less likely to have to move. But what about the other default variable, the market value of the mortgage (relative to the value of the house)? During the 1978-83 period, negative amortization would have led to continual increases in the mortgage balance. By the beginning of 1983, the balance would have been up by 17½ percent (and would be even higher at the beginning of 1985) and would be 21 percent greater than that of an uncapped ARM. This would, of course, increase the likelihood of default.

C. Foreclosures and Lender Losses

Of concern to lenders is not so much whether or not default occurs, but what losses lenders will incur if it does. If default occurs because the borrower has to move, not because of negative housing equity, and the lender has private mortgage insurance, then the lender's loss will be small at most. But if default is triggered by substantial negative equity, which is more likely to be the case when substantial negative amortization can occur, then lenders are likely to suffer significant losses even if they have standard private mortgage insurance. Payment caps, then, are very desirable from the viewpoint of mortgage insurers (the caps reduce defaults due to forced moves, defaults that cost the insurers), but these caps are potentially costly to lenders; the large cost of losses when negative amortization has occurred is likely to far exceed the small savings from fewer losses due to forced moves.[5]

Interest rate caps will reduce lender losses, both by mitigating the rise in the payment-to-income ratio and creating reduced mortgage value during periods of increasing interest rates. Again, however, private mortgage insurers (PMIs), rather than lenders, are the principal beneficiaries of the caps.

How large are expected lender (and insurer) losses from default on different mortgage instruments? There is some evidence regarding fixed-rate mortgages. In a five percent expected inflation world with 13 percent mortgage rates, Cunningham and Hendershott (1984) calculate that the default premium necessary to cover expected losses on an 80 percent loan-to-value mortgage is only 5 to 10 basis points. On ninety and ninety-five percent loans,

[5] This assumes that the insurer pays a flat percentage of the claim. If the insurer will pay the amount of the claim above, say, 75 percent of the original mortgage, then the insurer, not the lender, bears the risk of negative amortization.

respectively, the premia rise to 20-40 and 50-75 basis points. These premia are less at lower interest rates and, especially, at higher inflation rates. The comparable premia currently (November 1984) being charged by PMIs are 30 (80 percent), 40 (90 percent), and 55 (95 percent) basis points (these premia include amortization of large first-year premia over 12 years and cover expenses, as well as losses).

As for the extra default premium on ARMs, we have little more to go on than what PMIs are charging. With tight interest rate caps, the additional premium over FRMs is only 5 (80 percent loan to value) to 10 (90 and 95 percent) basis points. With payment caps, another 5 basis points are charged. Recall, however, that lenders, not insurers, generally bear the burden of increased potential losses due to payment caps (negative amortization). To summarize, the default premium on an 80 percent loan-to-value ARM (or higher loan-to-value loan with private mortgage insurance that leaves the effective risk of the lender equal to that on an 80 percent loan-to-value loan) should probably be 10 to 20 basis points and on a 90 percent loan-to-value ratio ARM should be 45 to 65 basis points, with the larger values being appropriate when payment caps are employed. These premia would be lower the greater is the expected drift in house prices and the lower is the expected volatility.

IV. Summary

The margin on an ARM over the cost of debt must cover expected losses owing to the use of interest rate caps and the likelihood of foreclosures, as well as operating and servicing costs. Moreover, a little extra is needed to give investors in risky equity a greater after-tax return than investors in risk-free debt. The cost of debt upon which this margin is added is the marginal <u>expected</u> cost until the ARM reprices, not the average cost of debt over a recent accounting period. Current and expected future, not past, debt rates are relevant. This logic suggests that the appropriate index rate is the yield on par-value Treasuries with maturity equal to the repricing period of the ARM.

Expected losses from interest rate caps depend on the expected drift and volatility of interest rates. The higher is the drift and the greater the volatility, the more likely are rates to rise sufficiently to cause caps to bind. Risk-adjusted expected losses also depend on the aversion lenders have to rate caps binding while the cost of funds continues to rise. Thus, margins on capped ARMs should vary over time as risk aversion and the expected drift and volatility of rates vary.

The observed term structure of interest rates reflects both the expected drift in interest rates and current market risk aversion. The more upward sloping is the term structure, whether due to an expected upward drift or to aversion to committing funds longer term, the more should lenders charge for rate caps. Similarly, the greater is interest rate volatility, the higher the margin should be. Margins can be quite sensitive to these parameters. To illustrate, the additional margin for a 5 percent life of loan cap suggested by application of an options pricing model has ranged between 5 and 40 basis points during the 1979-84 period. Analysis of how returns on capped one-year ARMs would have performed over the 1970-84 period relative to an uncapped ARM is consistent with this range. The extra margin for a 5 percent life-of-loan cap necessary to earn lenders the same return as on an uncapped ARM varied from 0 to 80 basis points.

Default depends on the equity a borrower has in the house collateralizing the mortgage and on the borrower's perceived default costs. Equity will be lower, the lower was the initial downpayment, the less the mortgage has declined in value and the more the house has fallen in value. Default costs are lower if the household has to move (moving costs do not deter default and costs of selling the house act as an incentive) than if it does not. These considerations suggest that foreclosure losses on ARMs will be greater than those on FRMs (assuming the same loan-to-value ratio and house price distribution) during periods of rising interest rates. The market value of FRMs will decline, raising homeowner's equity (households will not want to relinquish a below-market interest rate), and the payment-to-income ratio on the ARM will rise, increasing the likelihood of forced moves. Foreclosure losses on ARMs with tight rate caps will be less than those on ARMs with no or loose caps because the former will decline in value, although by less than the FRM, and will have smaller increases in payment-to-income ratios, but still greater than the FRM.

The impact of payment caps on the incidence of default during a period of rising interest rates is uncertain. Housing equity will decline as negative amortization occurs, but the number of forced moves will also drop. Losses from foreclosures seem certain to rise, however, because the negative amortization will result in considerably greater losses when foreclosure does occur.

With estimates of the expected cost of debt until repricing and the necessary rate-cap and default premia, required coupon rates on a wide variety of ARMs can be computed. Presumably some set of these will be attractive to households. We are not certain of this, however. An intense household affordability problem and an ability of ARMs to address it have contributed importantly to the acceptance of ARMs in 1984. ARMs will be more difficult to market if the level of interest rates falls markedly, reducing the affordability problem, or the term structure becomes sharply downward sloping, restricting the ability of ARMs to increase affordability. If the yield curve inverts, thrifts would be advised temporarily to reduce their share of the mortgage market. If the level of rates drops sharply, a movement back toward fixed-rate mortgages, presumably financed by longer term deposits (six- to eight-year zero coupons?), may be necessary.

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