A Discretionary Approach to Hedging a Lender's Exposure in Adjustable Rate Mortgages

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INTRODUCTION

Federally chartered lending institutions first received permission to offer adjustable rate mortgage loans (ARMs) in 1981. Since then, the instrument has grown to represent a significant segment of the single family residential mortgage market. The typical ARM is a cross between a conventional long-term fixed-rate loan and a short-term credit agreement indexed to a market rate. Although the ARM is a long-term loan, its rate is fixed only for a stated interval (usually one year). The loan rate changes on each anniversary date to a level determined by adding a pre-specified margin to the current value of a market-determined index. In most cases, large swings in the loan rate are dampened by concurrent-interval upward and downward rate change limits. In addition, borrowers are often protected against sustained rate increases by the existence of a life-of-loan cap.

While an adjustable rate loan clearly offers a lender more protection against interest rate risk than a long-term fixed-rate mortgage, ARM loans with concurrent-interval limits are subject to short-run interest rate adjustment constraints. Since borrowers face nontrivial refinancing costs, exposure to capital losses if market rates rise significantly is a more realistic concern for lenders than prepayment risk if rates fall. Also, many lenders offer ARMs at initial rates significantly below the fully-indexed level determined by adding the current value of the market index and the margin. Thus, upward-direction rate exposure is increased. Since lenders do not know the future path of interest rates when a specific ARM is originated, a hedging model that is to be applied at the lender's discretion must consider the interaction between rate change limits and potential adjustment index movements.

This study develops and tests the effectiveness of a discretionarily applied naive expectations model designed to hedge against the exposure to an interest rate in-

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crease during the initial adjustment period typical in ARM lending. Despite this somewhat limited focus, the hedging program is general enough that it can be applied to ARMs of any age and can be modified easily to hedge against downward direction interest rate exposure (prepayment risk). Simulation results indicate that the model hedges exposure successfully with standardized futures vehicles and that it consistently outperforms the less sophisticated program of continuous hedging.

The next section of the article contains a brief review of previous research in the area of hedging interest rate risk in lending. Section III develops the hedging model and section IV presents comparative historical simulation tests of the effectiveness of the hedging strategy. The study's conclusions and suggestions for possible extensions of the research appear in Section V.

II. A BRIEF REVIEW OF PERTINENT PRIOR RESEARCH

The problems caused by the interest rate exposure inherent in lending by financial intermediaries are well documented. Batlin (1983) demonstrates that under certain assumptions a lender is not able to effectively hedge a long-term fixed-rate loan funded by short-term deposits. If the loan can be prepaid the lender gives up the "natural" hedge created by falling deposit and loan rates. While Batlin suggests that the optimal alternative is hedging by borrowers instead of lenders, recent work by Follain, Lea, and Park (1988) successfully incorporates mortgage prepayment risk into a hedging model.

Goldfarb (1987) extends the hedging analysis to include capped variable rate lending with prepayment risk and demonstrates the influence of conflicting forces in this hedging problem. For example, the existence of prepayment risk if rates fall leads an intermediary to sell fewer futures contracts, *ceteris paribus,* to protect against rising interest rates. This condition occurs because futures losses will exacerbate prepayment losses if rates do fall. On the other hand, the existence of a loan rate cap suggests that the intermediary should sell more futures contracts under identical conditions because the cap feature serves to increase possible losses.

Given this inherent conflict, Goldfarb argues that a lending intermediary should attempt to implement a hedging program that protects its entire balance sheet (macro-hedging) instead of trying to immunize on an asset-by-asset basis (micro-hedging).[1] Despite Goldfarb's conclusion, this study's selective hedging strategy is consistent with his results on a time-specific basis. For any lender, only one of Goldfarb's assymmetries can hold at a single point in time since the conditions that create prepayment risk preclude the existence of the rate cap risk, and vice-versa. The test of the hedging model developed in this article concentrates on the latter risk although the hedging strategy can easily be adapted to consider the former risk as well.

Morgan, Shome, and Smith (1988) develop a fully-integrated model of a lending intermediary and show that the optimal forward position depends upon the relationships between; (1) loan rates and market rates; (2) capital and assets; and (3) loans demanded and deposits supplied. Since their empirical results clearly indicate that these relationships vary across specific institutions, the model developed

[1]See Kolb, Timme, and Gay (1984) for a description of the distinctions between macro-hedging and micro-hedging.

in this article is tested on the ARM offerings of a single savings and loan association in South Florida.[2]

A savings institution is chosen to provide a test scenario for the model of hedging interest rate exposure in ARM lending for several reasons. The problems caused by the asset/liability maturity mismatch traditionally adopted by these lenders are well known. Indeed, Flannery and James (1984) and Scott and Peterson (1986) present conclusive evidence that market returns for stock savings and loan associations exhibit significantly greater sensitivity to interest rate movements than do the market returns of commercial banks or life insurance companies, intermediaries which usually carry better asset/liability maturity balance. Second, Morris and Merfeld (1988) document significant negative correlation between the return on savings and loan industry assets and market interest rates. Third, Gurel and Pyle (1984) demonstrate that institutional lenders should be especially concerned about hedging interest rate exposure if they benefit from the existence of nonsaleable federal income tax shields that cannot be utilized if net income falls below a certain level. Together, these findings suggest that managers of savings and loan associations should be particularly interested in new models of interest rate risk management.

Morris and Merfeld also present evidence that adjustable rate mortgage loans have become a significant factor in savings and loan portfolios. In June, 1987, the industry carried 31% of its assets in ARMs and 39% in fixed rate loans. Given the associations' recent reliance on ARM lending, it appears that a model representing an initial attempt to integrate the existing hedging literature and new developments in mortgage lending could provide valuable insights.

Most early work in the area of hedging mortgages with financial futures uses what has become known as the "portfolio" approach. For example, Ederington (1979), Follain, Lea, and Park (1988) and Gau and Goldberg (1983) determine optimal risk minimization hedge ratios for specific assets by calculating the relationship between the variance of futures prices and the covariance between spot and futures prices. Recent work expands the focus of portfolio hedging to include the problem of protecting an institution's entire balance sheet by incorporating inter-relationships between changing lending costs, funding costs and regulatory constraints. Morgan, Shome, and Smith (1988), Goldfarb (1987), and Koppenhaver (1984), (1985a), and (1985b) provide examples of the effectiveness of broad-based covariance models when they are supplied in a macro-hedging framework.

This study is concerned with a micro-hedging problem rather than an integrated analysis of the earning and funding effects of ARM lending over time.[3] Its focus is restricted to the initial adjustment period interest rate exposure inherent in ARM lending with "teasers." Recent work expands the focus of micro-hedging by specifically incorporating the fact that cash and futures market assets have different price elasticities with respect to changes in interest rates. For example, Kolb,

[2]The institution participates actively in the national secondary mortgage markets. Its offering parameters are quite similar to those advertised by other local, and national, lenders. Additionally the lender competes in the local market with several national mortgage companies. Therefore, its ARM rate quotes should provide a representative set of parameters for the comparative tests of the discretionary and continuous hedging strategies.

[3]To be more specific, the model developed in this study easily allows an ARM loan to be funded with maturity-matched deposits over each adjustment interval. In that case, the lender is clearly more concerned about the possibility of constrained upward rate adjustment at the end of the adjustment period than about less than perfect correlation between loan and deposit rates.

Corgel, and Chiang (1982) and Kolb and Chiang (1981) demonstrate the superiority of a "price sensitivity" approach where hedge ratios incorporate the fact that spot and futures assets exhibit different durations.[4] The price sensitivity approach is adopted in this study for two additional reasons. First, Toevs and Jacobs (1986) note that it can be applied more quickly and efficiently than complicated, regression-based, portfolio models. Second, Luytjes and Spahr (1988) argue that from a regulatory perspective duration-gap models provide a better measure of the interest rate risk inherent in savings and loan association balance sheets than do maturity gap models.

An appropriate model of ARM hedging should incorporate uncertainty regarding the interaction between the future path of interest rates and ARM rate change constraints. The cornerstone of the discretionary approach to hedging is the argument that a hedge should only be created when the expectation of an adverse market development is strong enough to justify accepting the return-reduction properties of the hedge. In addition, a viable hedging strategy must consider the differences in the durations and valuation characteristics of the spot and futures instruments. The next section of the article develops a hedging model that meets both criteria and is easily applied in a variety of adjustable rate lending situations.

III. THE HEDGING MODEL

The Interest Rate Forecast

This study argues that hedging of ARM loans is warranted only when the lender expects that the upward-direction rate change constraint will hold on the adjustment date. Formalizing this expectation requires a specification of the underlying interest rate adjustment process. While much academic attention has been directed to the valuation of ARM loans via continuous-time interest rate models[5], this study adopts the naive expectations forecast of today's interest rate being an unbiased estimate of future rates to provide as clear a test of the discretionary hedging model as possible. Under this interest rate scenario, the upward-direction rate change constraint is expected to hold and hedging is warranted at time period (t) if:

$$(LR + L) < (E(IN_{t+1}) + M) = (IN_t + M) \tag{1}$$

where:

- LR = the current ARM loan rate,
- L = the current rate change limit,
- IN_t = the current value of the market-determined adjustment index,
- M = the pre-specified margin added to the adjustment index to determine the new loan rate, and
- $E(\cdot)$ = the expectations operator.

In words, eq. (1) argues that hedging a future ARM loan rate adjustment is warranted if today's fully-adjusted rate would face an upward-direction constraint.

[4]The original price sensitivity approach relies on the duration measure first proposed by Macaulay (1938), although recent evidence presented in Toevs and Jacobs (1986) demonstrates that the strategy itself is amenable to more complicated duration specifications.

[5]See Hendershott (1986) for a review of early work which attempts to value ARM loans under stochastic interest processes, and Kau, Keenan, Muller, and Epperson (1988) for a state-of-the-art approach to the problem of ARM valuation under future interest rate uncertainty.

It is important to note that the interest rate process adopted here does not assume that interest rates will remain constant. It argues instead that the best forecast of the unconstrained loan rate expected to hold at the next adjustment date is the current value of the unconstrained ARM rate. This naive expectations formulation provides an interest rate forecast identical to that of the binomial process popular in option pricing models if there are equal probabilities of increases and decreases of the same magnitude in the binomial specification.[6] A naive expectations formulation is also consistent with interest rates following a Weiner process with zero drift.

The Hedge Ratio

Once the timing of the discretionary hedging decision is quantified, the appropriate number of futures contracts to be sold to provide the necessary hedging protection must be determined. As shown in Kolb and Chiang (1981) and Kolb, Corgel, and Chiang (1982), the hedge ratio (N) that takes the differential price sensitivities of spot and futures instruments to changes in interest rates into account in developing a hedging strategy is calculated as:

$$N = -\frac{R_j P_a D_a}{R_a FP_j D_j}(\partial R_a/\partial R_j) \tag{2}$$

where:

N = the number of futures contracts traded,
R_a = 1 + the yield on the hedged asset,
R_j = 1 + the yield on the asset underlying the futures contract,
P_a = the price of the hedged asset expected to appear on the planned termination date of the hedge,
FP_j = the price of the asset underlying the futures contract expected to appear in the planned termination date of the hedge,
D_a, D_j = the durations of the hedged asset and the asset underlying the futures contract expected to appear on the planned termination date of the hedge, respectively, and
$\partial R_a/\partial R_j$ = the partial derivative of a change in the yield on the hedged asset with respect to a per-unit change in the yield on the asset underlying the futures contract.

The value of the partial derivative term is usually calculated as β_1 in the following simple linear regression equation on time-series data:

$$R_{a,k} = \beta_0 + \beta_1 R_{j,k} + \epsilon_{a,k} \tag{3}$$

Combining the discretionary approach to the timing of the hedge creation determined in eq. (1) and the duration based hedge ratio of eq. (2) completes the development of the hedging model. Given a decision to hedge, the hedging objective is to minimize the variation over time in the portfolio value:

$$\left\{\sum_{t=1}^{m} \Delta VARM_t + \Delta P_{jt}(N)\right\}\Gamma_t \tag{4}$$

[6]The authors would like to thank an anonymous referee for this Journal for calling attention to this issue.

where:

$\Delta VARM_t$ = the week-to-week change in the present value of the second year's payments on an ARM loan discounted to the adjustment date,

ΔP_{jt} = the week-to-week change in the price of the futures contract traded to create the hedge, and

Γ_t = a binary variable that takes on the value of one for time period (t) when $(E(IN_{t+1}) + M) > (LR + L)$ and is zero otherwise.

The hedging strategy analyzed here considers only the second year's payments on an ARM loan when measuring current interest rate exposure. This focus is adopted as the best measure of the interest rate risk created by originating loans with "teasers" since the mathematical structure of the adjustment process is such that loans whose rates are constrained at the first adjustment, (the beginning of the second year), are not constrained at the second adjustment, (the beginning of the third year), if the value of the adjustment index remains constant. A stationary expected value for the adjustment index is a direct result of the naive expectations adjustment process assumed here.

As mentioned previously, the hedging program of (4) is general enough to consider ARM loans of any age and to incorporate either rate cap or prepayment risk.[7] Institutional idiosyncracies in the primary ARM market and recent movements in the adjustment index have combined to create a situation where the exposure of greatest concern occurs during the first year on an ARM issued with a "teaser," however. Since mortgage refinancing costs are substantial, large decreases in the adjustment index are required before prepayment becomes a viable alternative for the ARM borrower. On the other hand, the presence of teasers means that many borrowers find that their ARM rates increase dramatically during the second year even though the adjustment index declines. Furthermore, small increases in the adjustment index often cause the upward rate change to be constrained; limiting the second year's payments. Therefore, this test of the ARM hedging model considers only initial-year, rate increase exposure.

The effectiveness of this limited version of the hedging model as a risk reducing tool is easily determined by simulating its performance using historical data on actual ARM originations with specific adjustment characteristics. These simulation results are presented in the next section of the article. The tests consider hedging using the Treasury bill futures contract whose maturity is nearest to, but beyond, the adjustment data.[8] The hedging results are evaluated with reference to the performance of the nondiscretionary hedging strategy of continuously applying a hedge and the simulation is applied during a wide range of interest rate environments.

[7]At points in time where interest rates have dropped so significantly since origination that ARMs loans are candidates for refinancing, the appropriate definition of the binary variable is

$$\Gamma_t = \text{one if } (E(IN_{t+1}) + M) = (IN_t + M) < (LR - L - RFC)$$

where:

RFC = an estimate of the refinancing cost faced by the typical ARM borrower.

[8]In the interest of completeness, simulation results achieved by using the nearby Treasury Bill futures contract are available from the authors. Hedging performance using the nearby contract seldom compared favorably with that attained by using maturity-matched contracts and the latter strategy has the added benefit of eliminating the need to roll over a hedge during an adjustment period.

IV. THE HEDGING SIMULATION

The ARM Data

Origination parameters are from a mutual association that is one of the five largest mortgage lenders in South Florida. The institution, which agreed to provide the data only with a guarantee of anonymity, first offered ARM loans in November 1983. It has consistently stood ready to originate one year ARM loans indexed to the corresponding constant maturity Treasury yield.[9] Since November 1984, the association has continuously carried a portfolio of 52 sets of ARM loans that are in the initial adjustment period. The simulation analysis is undertaken only during this "steady state" condition. The characteristics of the actual offerings during the sample period are displayed in Figure 1.

Figure 1 indicates that a great deal of variation has occurred in both adjustment characteristics and financial market conditions. Margins and limits increased significantly during the sample period. In addition, the difference between the initial rate and the fully indexed rate at each point in time (the size of the "teaser") has widened considerably. These results make sense from a risk/return perspective since larger limits and margins lead to greater flexibility in future interest rate ad-

[9] All of the loans in the sample are for owner-occupied single family residences, have loan-to-value ratios of 80% or less, and have 30 years to maturity with monthly payments. In addition, they carry origination fees which average 2% to 3% during the time period in question but are ignored to preserve simplicity in the hedging simulation. Examination of the publicized offerings of major institutional lenders in the local area indicates that the loans analyzed here are quite similar to other available to borrowers at the same points in time.

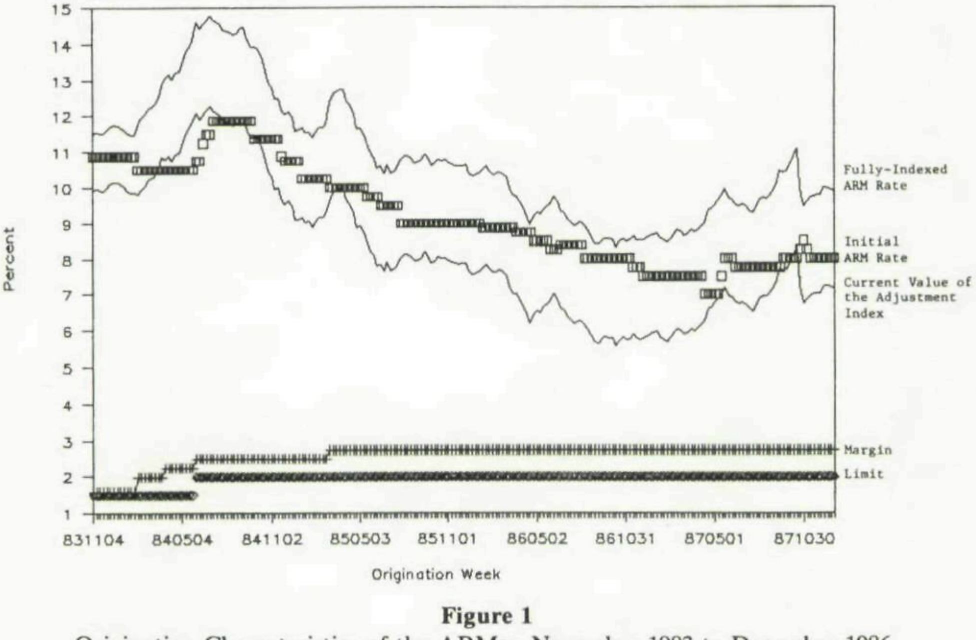

Figure 1
Origination Characteristics of the ARMs—November 1983 to December 1986.

justments, offsetting the price concessions implied by the increasingly larger "teasers."

Figure 1 also serves to reiterate the importance of the lender's exposure to rate cap risk during the initial adjustment period. The sum of the current value of the adjustment index and a specific ARM margin exceeds the sum of the initial ARM rate plus the limit (providing a positive discretionary hedging signal) for 2919 of the 11,130 hedge date/ARM origination date combinations in the sample period. In contrast, $(IN_t + M)$ is never less than $(LR - L)$, minimizing the potential damage caused by future prepayment under costless refinancing, the most conservative assumption.

THE SIMULATION PARAMETERS

The goal of both the discretionary and the continuous hedging models is to provide protection against the risk that the fully-indexed ARM rate $(IN_t + M)$ will exceed the constrained rate $(LR + L)$ at the end of the first year. If the fully-indexed rate is greater than the constrained rate, the ARM lender suffers a loss through a mandatory one-year interest rate subsidy. The amount of the rate subsidy is the difference between the second year's payments computed at the fully-indexed rate and the second year's payments computed at the constrained rate. Throughout the simulations, it is assumed that the ARM lender originates one $100,000 loan on the last business day of each quote week. It is assumed also that the first ARM rate adjustment date is the last business day of the 52nd week after the quote week.

Specification of the dollar value of the initial year ARM "cash market" exposure leads to the argument that P_a from eq. (2) is the present value of the contractually-limited second year payments at the end of the first year (the planned termination date of the hedge). The discount rate used to determine P_a is the current fully-indexed rate which measures the opportunity cost of constrained lending. This discount rate changes at each hedge formation date (weekly), for each loan (indexed by origination week). R_a is assumed to be (1 plus the current value of the fully-indexed rate) which allows the calculation of the duration of the dollar payments, D_a.[10] Finally, week-to-week changes in the value of P_a summed over all ARM loans that are less than one year old on a given hedge formation date provides a time series measure of changes in the value of the "cash market" position ($VARM_t$) in eq. (4).

Market data for the hedging simulations is from a variety of sources. Weekly values for the one-year constant-maturity Treasury yield (IN_t) are from the *Federal Reserve Bulletin.* The remainder of the components of eq. (2), (3), and (4) require futures market price data. Weekly Treasury Bill futures prices are from the Dow Jones News Retrieval Service futures data base. All futures prices are Friday, or end-of-week, settlement prices.

Since the duration-based hedge ratio requires estimates of futures prices, yields, and durations as of the planned termination date of the hedge, naive expectations are assumed here also. Then, the futures price on the hedge formation data proxies for FP_j, R_j is equal to (1 plus the yield implied by FP_j), and D_j is .25 since the delivery instrument underlying the futures contract is a 90-day Treasury Bill. For simplicity, transactions costs and margin requirements are ignored.

[10]The simulation utilizes the duration of a 12-month annuity rather than the duration of the 30-year ARM loan (which has been derived analytically by Ott (1986)). The short-term focus of the specific hedging problem addressed here suggests reliance on the duration of the payment stream assumed to be at risk, one year's cash flows, rather than the entire set of future ARM cash flows.

The specific hedging vehicle chosen for each mortgage is the first contract that expires on or after the first rate adjustment date. The value of the partial derivative $\partial R_a/\partial R_j$ is determined by regressing R_a on R_j. The estimation process reveals instability in the partial derivative over the 1985–1987 sample period so separate regressions are run weekly for each contract using the thirty previous weeks of data.

Once the dollar value of futures contracts to be sold is determined, the continuous hedging simulation is complete. In contrast, the discretionary model argues that the hedge should only be placed if the upward-direction rate adjustment is constrained today. The two hedging models are identical if $(IN_t + M) - (LR + L) > 0$ while the discretionary model collapses to a strategy of not hedging when $(IN_t + M) - (LR + L) \leq 0$.

The only question that remains to be answered before the simulation parameters are operationalized is the specification of the appropriate measure of the value of the cash position that is "at risk." There are two possible definitions of exposure when comparing discretionary and continuous hedging: (1) the "constrained cash position," where gains and losses are accrued only if the fully-indexed rate, (the current index plus the margin), exceeds the constrained rate, (the loan rate plus the limit), at the beginning of the week, or (2) the "continuous cash position," where gains and losses are accrued weekly regardless of the eventual change in the adjustment index. The correlation between the two cash position risk measures and the philosophies that support the respective hedging strategies are clear-cut. This study argues that the first pair, discretionary hedging of the constrained cash position, provides a more realistic picture of the risks inherent in ARM lending than does the second couplet, continuous hedging against week-to-week changes in the value of the cash position.

Simulation Results

There are four relevant weekly time series in the initial simulation analysis: continuous and discretionary hedging netted against constrained or continuous cash position changes. Summary statistics for the four separate returns distributions, over the entire sample and annual subperiods, appear in Table I. It is not suprising that the hedged portfolio returns are usually less than the cash position returns since the one-year constant-maturity Treasury yield, (the adjustment index which drives many facets of the hedging models), declined throughout most of the sample period. The contribution of a hedging program, however, lies in its risk-reducing properties, not its profit-enhancement potential. Thus, the appropriate measure of success in hedging is the proportion of the variance in the changes in the weekly cash position offset by the changes in the weekly futures position:

$$1 - (VAR_{CP|FP}/VAR_{CP}) \tag{5}$$

where:

$VAR_{CP|FP}$ = the conditional variance of the cash position given that futures trades are undertaken, and

VAR_{CP} = the variance of the unhedged cash position.

Hedging effectiveness is quantified by the coefficient of determination (R^2) of the regression equation:

$$CP_t = \alpha + \beta(FP_t) + \epsilon_t \tag{6}$$

Table I
DISCRETIONARY AND CONTINUOUS NET HEDGING RESULTS SEGREGATED BY RISK DEFINITION FOR CASH POSITION

Exposure Definition	Time Period	Hedging Model	μ^b	σ	R^2	F	Number of Weeks Hedging Takes Place	Mean Number of Loans Hedged Each Week	Mean Hedge Ratio For Each Hedged Loan
Cash	Full	Disc.	−12.5	112.1	.84	222.8*	43	22.5	−0.2342
Position	Sample	Cont.	−89.9	435.9	.22	43.6*	159	52.0	−0.1520
Accrues									
Gains and	1985	Disc.	−14.0	107.0	.02	0.2	12	13.3	−0.4143
Losses	Orig.	Cont.	−183.3	628.4	.03	1.8	52	52.0	−0.1974
Only When									
the Fully-	1986	Disc.	0.0	0.0	-	-	0	-	-
Indexed	Orig.[a]	Cont.	−90.7	287.2	-	-	53	52.0	−0.1211
Rate									
Exceeds the	1987	Disc.	−22.3	161.9	.90	255.2*	31	26.1	−0.1644
Constrained	Orig.	Cont.	0.8	297.6	.64	91.6*	54	52.0	−0.1387
Rate									

Cash Position Accrues Gains or Losses Each Week	Full Sample	Disc.	58.0	450.6	.54	47.7*	43	22.5	−0.2342
		Cont.	−20.2	475.5	.32	74.4*	159	52.0	−0.1531
	1985 Orig.	Disc.	127.5	590.1	.00	0.0	12	13.3	−0.4143
		Cont.	−42.8	695.2	.14	7.9*	52	52.0	−0.1989
	1986 Orig.[a]	Disc.	130.4	382.9	-	-	0	-	-
		Cont.	39.2	305.6	.38	31.5*	53	52.0	−0.1221
	1987 Orig.	Disc.	−80.1	311.2	.78	104.0*	31	26.1	−0.1644
		Cont.	−56.8	333.4	.65	95.5*	54	52.0	−0.1393

Cash Position Summary	**Time Period:**	**Full Sample**	**1985**	**1986**	**1987**
Constrained Cash Position	μ^b	4.0	16.6	0.0	−4.3
Changes Only	σ	273.5	74.8	0.0	466.3
Weekly Cash Position	μ^b	74.1	158.1	130.4	−62.2
Changes	σ	527.0	594.8	382.9	560.8

[a]The fully-indexed rate never exceeds the constrained rate in 1986.
[b]Average weekly gains or losses on the complete ARM portfolio in dollars.
*F statistics significantly different from 0 at the 5% level.

where:

CP_t = the change in the value of the cash position from time $(t - 1)$ to time (t),

FP_t = the change in the value of the futures position from time $(t - 1)$ to time (t), and

ϵ_t = a random error term.

Then, the test statistic for the significance of the risk reduction is the F–statistic from the Ordinary Least Squares regression. For the discretionary hedging strategy, eq. (6) is estimated only over time periods when hedging takes place.

There are two reasons why the hedging effectiveness measures are calculated on a weekly basis despite the fact that, for an individual ARM, the model assumes that the hedger's planning horizon runs from the hedge decision date to the first interest rate adjustment date. First, new values for the adjustment index become available each week, requiring a new hedging decision for each loan at risk. Second, the weekly scenario best approximates the dynamic process of ARM origination and rate adjustment. Over time, new loans enter the portfolio and old loans experience their first rate change. The weekly hedging evaluation period allows the discretionary hedging parameters to change over time to reflect this process.

The hedging effectiveness measures and the associated test statistics are reported in Table I. It can be seen that all of the hedging combinations provide significant risk-reduction benefits when the entire sample is considered. Not surprisingly, the relative performance of the respective hedging models is often consistent with the assumed definition of cash market risk. For example, the constrained cash position is usually better hedged via the discretionary program and vice-versa, (a notable exception occurs in the 1987 subsample, a result which is addressed below). Closer inspection of Table I indicates that the discretionary hedging model outperforms the continuous hedging approach over the entire sample and the time-dependent segments when the constrained cash position is adopted as the appropriate measure of asset value at risk. This conclusion holds when performance is measured in terms of statistical hedging effectiveness or in terms of the standard deviation of the hedged position's returns.

Table I also presents summary statistics on the frequency of hedging and the size of hedges when hedging takes place. Over the entire sample period, continuous hedging results in a total of 8268 loan-week hedges while the discretionary model requires only 968 loan-week hedges. Thus, the discretionary hedging strategy clearly carries lower transactions costs than continuous hedging. Also it can be seen that when hedging takes place, the discretionary model leads to higher hedge ratios than does the continuous model. This result is logical because the discretionary model reacts to changes in the level of interest rate exposure over time. As would be expected, the discretionary model dictates more hedging in times of rising interest rates, for example 1987, and less hedging in periods of falling interest rates, for example 1986.

Hedging performance in 1987 is important from a practical perspective because it is the only annual subperiod in the sample where increases in the adjustment index, (see Fig. 1), are strong enough to create a net loss in the cash position under either exposure definition. The differential performance of the two hedging strategies during that year suggests that the simulation analysis can be refined further to address the relative effectiveness of the discretionary and continuous approaches. Table II presents the simulation results for the constrained cash position exposure definition when the sample period is separated by the *eventual* upward or downward movement in the adjustment index which occurs one week hence. This approach is analogous to the tests of hedging models with "perfect foresight" adopted by Koppenhaver (1984, 1985a, 1985b) and Morgan, Shome, and Smith (1988).

While the top panel of Table II, which contains results for weeks which precede eventual increases in the adjustment index, is clearly the most relevant to the discussion at hand, the discretionary hedging model exhibits larger hedging effectiveness measures than continuous hedging under both index movement environments. Focusing on the top panel of Table II, the relative risk reduction benefits of the discretionary hedging are clearly evident. The hedging model advocated in this study offers statistically significant protection from the upward-direction interest rate exposure inherent in ARM lending over the entire sample and the 1987 annual subperiod. Furthermore, the standard deviation of the return of the discretionarily hedged position is always less than that of the unhedged cash position, providing further evidence of the benefits of the discretionary approach. Taken as a whole, the simulation results in Tables I and II provide clear, consistent evidence that the discretionary model advocated by this study provides an effective way to immunize ARM portfolio returns against rate cap risk during the initial adjustment period.

V. CONCLUSIONS AND EXTENSIONS

While adjustable rate mortgage lending obviously incurs less interest rate risk than fixed rate lending, ARM lenders do face harmful interest rate exposure if annual rate change limits can be expected to constrain the upward movement in the loan rate on the adjustment date. This study adopts a naive expectations interest rate forecast to test a discretionary model of ARM hedging that is based on the argument that the interaction between market conditions and the adjustment characteristics specific to ARM loans at any point in time allows a lender to identify appropriate candidates for hedging. In the discretionary approach, hedging is advocated only when the current value of the adjustment index plus the pre-specified margin exceeds the sum of the loan rate and the annual adjustment limit.

The attributes of the discretionary hedging model are analyzed by simulating its performance using data from actual ARM originations by a lender in South Florida. Loans in their initial adjustment period are considered because the prevalence of origination "teasers" (first-year discounts from the current fully-indexed rate) obviously increases the probability of upward-direction interest rate exposure during that time.

Simulation results suggest that discretionary hedging outperforms the less-sophisticated strategy of continuous hedging under a variety of scenarios created by two possible definitions of asset exposure and two types of interest rate environments. The superiority of the discretionary model is clearly evident. It consistently exhibits larger hedging effectiveness measures than the continuous hedging strategy, especially when the probability of incurring cash market losses is significantly large.

The success of the discretionary hedging approach to ARM lending introduced in this study suggests that further analysis and potential refinement of the hedging strategy are warranted. For example, a test of the model's performance after the initial year on a set of ARM loans or the extension of the analysis to other types of ARMs with different adjustment characteristics would serve to broaden the generality of the results. In addition, the adoption of a more sophisticated interest rate forecasting model might provide still greater hedging effectiveness.

Table II
DISCRETIONARY AND CONTINUOUS CONSTRAINED CASH POSITION NET HEDGING RESULTS SEGREGATED BY EVENTUAL MOVEMENT IN ADJUSTMENT INDEX

Index Movement	Time Period	Hedging Model	μ^b	σ	R^2	F	Number of Weeks Hedging Takes Place	Mean Number of Loans Hedged Each Week	Mean Hedge Ratio for Each Hedged Loan
	Full	Disc.	−27.9	116.0	.33	10.6*	24	23.2	−0.3399
	Sample	Cont.	54.6	409.7	.02	1.4	82	52.0	−0.1529
Adjustment									
Index	1985	Disc.	−14.3	49.2	.02	0.0	4	12.3	−0.9987
Rises	Orig.	Cont.	29.5	556.8	.03	.7	27	52.0	−0.1969
During									
Following	1986	Disc.	0.0	0.0	-	-	0	-	-
Week	Orig.[a]	Cont.	102.3	302.8	-	-	20	52.0	−0.1208
	1987	Disc.	−54.4	170.0	.29	7.3*	20	25.4	−0.2082
	Orig.	Cont.	46.6	331.1	.04	1.4	35	52.0	−0.1374

Adjustment Index Falls During Following Week	Full Sample	Disc.	4.6	106.0	.90	156.8*	19	21.7	−0.1510
		Cont.	−243.7	411.9	.30	31.5*	77	52.0	−0.1005
	1985 Orig.	Disc.	−13.7	147.4	.04	0.2	8	13.8	−0.1221
		Cont.	−413.1	630.4	.02	0.4	25	52.0	−0.1980
	1986 Orig.[a]	Disc.	0.0	0.0	-	-	0	-	-
		Cont.	−207.7	205.3	-	-	33	52.0	−0.1212
	1987 Orig.	Disc.	36.8	130.0	.99	627.3*	11	27.5	−0.0848
		Cont.	−83.4	205.3	.93	210.2*	19	52.0	−0.1411

Cash Position Summary	Time Period:	Full Sample	1985	1986[a]	1987
Adjustment Index Rises	μ^b	−61.6	−9.8	0.0	−136.8
	σ	156.3	33.9	0.0	217.1
Adjustment Index Falls	μ^b	73.8	45.0	0.0	239.8
	σ	346.3	94.9	0.0	647.0

[a]The fully-indexed rate never exceeds the constrained rate in 1986.
[b]Average weekly gains or losses on the complete ARM portfolio in dollars.
*F statistics significantly different from 0 at the 5% level.

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