1985

The use of interest rate futures by agricultural banks

Mark John Bowman
Iowa State University

The use of interest rate futures by agricultural banks

by

Mark John Bowman

A Thesis Submitted to the

Graduate Faculty in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

Department: Economics

Major: Agricultural Economics

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa

1985

TABLE OF CONTENTS

CHAPTER I. INTRODUCTION

Agricultural banks have traditionally had a high degree of insulation from interest rate movements because of a localized deposit structure and a stable operating environment, but recent changes in the national banking structure have caused the agricultural banking industry to face increased risk. Bank deregulation resulting from the Depository Institutions Deregulation and Monetary Control Act of 1980 (DIDMCA) has allowed urban banks and other institutions to compete directly with agricultural banks for funds. Moreover, since the 1970s rural savers have gained direct access to a wider assortment of savings instruments. As a result, agricultural banks have had to replace non-interest bearing demand deposits and low-interest savings accounts with higher yielding instruments, such as Money Market Certificates (MMCs), as their principal source of funds. They no longer have a large collection of interest-free deposits that they can use to insulate themselves from interest rate changes. In addition, interest rates have become much more volatile in the past six years. This is due in part to the fact that the Federal Reserve Board, in an attempt to hold down inflation, no longer aims its policy towards holding interest rates down, but instead towards limiting the money supply. The result of these changes is that agricultural banks are now subjected to increased interest rate risk.

The three methods often suggested for reducing interest rate risk - using variable rate loans, shortening loan maturities and matching maturities of assets with maturities of liabilities - have serious drawbacks in their applications. Variable rate loans essentially transfer interest rate risk from the lenders to the borrowers. But, an increase in borrower risk means an increase in another type of risk for lenders - the risk of their customers defaulting on their loans. Shorter maturities on loans reduce interest rate risk, and agricultural lenders have been using this method for some time (Lins, 1984, p. 117). It is essentially another way of applying variable rate loans. But, this practice only creates more stress for the farmers (since they have to refinance more often). It also limits the types of loans these banks can offer, thereby reducing the competitiveness of these banks and diminishing their effectiveness as intermediaries. Matching maturities of assets and liabilities would allow agricultural banks to guarantee their profit margins on specific loans. Unfortunately, due to the small size of most of these banks and the seasonal nature of their loan operations, it may be difficult for them to do so. Furthermore, they would be sacrificing profit potential that might exist from using lower rate, short-term liabilities for funding longer-term loans. And besides, isn't the intermediation of mismatched maturities one of the primary duties of banks? These drawbacks suggest a need for an alternative method of reducing interest rate risk, such as hedging with interest rate futures.

The volatile interest rates of recent years have given rise to the successful development of interest rate futures contracts on the major exchanges. The effectiveness of these contracts in hedging against interest rate fluctuations, both through direct hedging and cross-hedging, has been analyzed by Ederington (1979), Franckle (1980), Ciccheti, Dale and Vignola (1981), Senchack and Easterwood (1983) and Overdahl (1984), among others. Furthermore, Drabenstott and McDonley (1982a) have maintained that interest rate futures can be effectively used by agricultural banks as well as large, money center banks, particularly in managing liabilities. They suggest, as one possibility, using T-bill futures to cross-hedge 6-month MMCs.

By hedging its liabilities, an agricultural bank attempts to transfer its interest rate risk to the speculator in the futures market. With this transfer of risk, the bank protects itself against unexpected rate increases, but it also passes any potential to gain from rate increases on to the speculator. If the bank can forecast, with some degree of confidence, which direction interest rates will move, might it not gain from following a strategy of hedging when it expects rates to increase and not hedging when it expects rates to decrease? Can it adopt this "selective hedging" strategy without exposing itself to any more interest rate risk than it would have faced had it hedged all the time? The objective of this study is to evaluate selected decision rules which will allow agricultural banks to pay significantly lower liability rates than they would by adopting an "always hedge" strategy, without exposing themselves to additional interest rate risk.

In this study, selective hedging strategies will be examined for a hypothetical agricultural bank hedging 3-month and 6-month MMCs. The bank will base its decisions of whether or not to hedge on forecasts of future interest rates. Two sets of forecast data will be tested. One set is based on T-bill futures prices, while the other set is based on quarterly forecasts of 90-day T-bills supplied by the American Statistical Institute. The MMC rates the bank faces as a result of following the selective hedging strategy will be compared to the rates resulting from the "always hedge" and "never hedge" strategies. In addition, established methods of judging hedging effectiveness (Senchack and Easterwood, 1983) will be used to determine whether the selective hedging strategy reduces interest rate risk as well as the "always hedge" strategy.

In Chapter II, background material on the MMC market and the interest rate futures market is provided. The hedging process is explained, and various hedging strategies are discussed. Chapter III contains the theoretical background for this study, including an outline of previous work and an introduction to the theory that will be used in the empirical section. In Chapter IV, the empirical results are presented and interpreted. The study is concluded in Chapter V.

CHAPTER II. BACKGROUND INFORMATION ON LIABILITY MARKETS, INTEREST RATE FUTURES AND HEDGING

Chapter II contains background material that is required for a clear understanding of interest rate futures and how they can be used by agricultural banks. The chapter begins with a discussion of the liability markets faced by agricultural banks. It continues with an explanation of the interest rate futures markets and the concepts of hedging and cross-hedging. Finally, hedging strategies for agricultural banks are discussed.

Money Market Certificates

Prior to 1978, agricultural banks acquired the majority of their loanable funds from non-interest bearing demand deposits and heavily regulated savings and time deposits. The only money market instruments available to them were large ($100,000 or more) Certificates of Deposit (CDs). Although the CDs were used to some degree, their large size prevented agricultural banks from utilizing them to any great extent. In 1977, large time deposits represented 7.9% of all financial claims against banks with total assets of less than $1 million at years end (Cole, 1981, p. 483).

In 1978, deregulation of the banking industry allowed the creation of a smaller-sized, short-term money market time deposit, the 6-month Money Market Certificate. The minimum size of these new instruments was $10,000, compared to the $100,000 minimum on regular CDs. The rate ceilings on the 6-month MMC was tied to the rates on 6-month U.S. Treasury

Bills. The 6-month MMC gained in popularity rather quickly, accounting for roughly one-third of all interest-bearing liabilities at small banks by 1981. It has been credited with being the instrument "most responsible for the changing structure at small banks" (Opper, 1982, p. 456).

Restrictions on MMCs have been relaxed in recent years. Their minimum deposit has been lowered to $1,000, increasing their accessibility to small investors. Banks have been allowed to offer them in 1-month and 3-month maturities, in addition to the original 6-month maturity. However, the use of MMCs by small banks is still largely attributed to the 6-month variety. Apparently, the shorter-term liabilities are not as popular with small banks. This phenomenon may have something to do with lending cycles associated with agriculture. Since most non-real estate agricultural loans tend to be between six months and one year in length, agricultural lenders would probably prefer to offer liabilities of at least six months or more.

Continued deregulation of the banking industry allowed a potential competitor to the 6-month MMC, the Money Market Depository Account (MMDA), to be introduced in December, 1982. The MMDAs offered money market rates (with no ceilings on them) on accounts with minimum deposits of $2,500. (Since that time, the minimum deposit has been lowered to $1000.) Customers were allowed six automatic or telephone transfers per month (three by check) and unlimited withdrawals in person. These accounts quickly became very popular; balances held in MMDAs totalled more than $340 billion within four months their introduction. By comparison, it took nearly two years for the 6-month MMC to reach that level (Furlong, 1983, p. 319).

The initial purpose of the MMDAs was to provide commercial banks with a tool for competing with the Money Market Mutual Funds (MMMFs), being offered by non-depository institutions. This objective was met to some extent, as is indicated by contractions experienced in the investment industry during the first four months of the MMDAs' existence. However, by mid-1983 it became clear that most of the MMDA balances came from other depository accounts, particularly savings and small time deposits, including 6-month MMCs. This occurrence can be partially attributed to the fact that MMDA rates were very high initially, making them not only more attractive than MMMFs but practically all savings and small time deposits.

Large, money center banks fared much better than small banks as a result of this movement of liabilities into MMDAs. Most large banks were able to widen their net interest margins because they switched many of their liabilities from higher-cost managed liabilities, such as large CDs, to lower cost MMDAs. Smaller banks had fewer managed liabilities to begin with, so most of the movement of their liabilities was out of lower-cost regulated deposits (such as demand deposits and passbook savings accounts) into MMDAs, now paying a market-determined rate. As a result, the net interest margins of small, agricultural banks declined during this time (Danker and McLaughlin, 1984, p. 802).

The introduction of MMDAs does not appear to have diminished the importance of MMCs as funding instruments for small banks. During 1983, there was a 4.5% increase in assets funded by retail-type savings and small time deposits (including MMCs), MMDAs and Super NOWs (the savings and loan industry's answer to MMDAs). During that time, there was a 3.5% decline in money market liabilities (large CDs) and a 1% decline in demand deposits. Small time deposits diminished in importance during the first half of 1983, but they rebounded during the second half as MMDA rates trended downward and small time deposits were deregulated in October of that year (Danker and McLaughlin, 1984, p. 804-805). This indicates that MMCs remain important funding instruments for small banks.

Interest Rate Futures Contracts

Interest rate futures were first offered in 1975 when the Chicago Board of Trade (CBOT) established their GNMA Collateralized Depository Receipt (CDR) contract. The following year the International Monetary Market (IMM) established a contract on 90-day U.S. Treasury Bills. Since then contracts on U.S. Treasury Bonds and U.S. Treasury Notes have been introduced at the CBOT, and contracts on CDs have been introduced at the IMM. In 1981, the Mid-America Commodity Exchange (Mid-Am) introduced "mini-contracts" on T-bonds and T-bills. These contracts form a secondary market based on the CBOT and IMM contracts and are one-half the size of the originals. The three contracts which will be considered for hedging short-term liabilities are the IMM T-bill, the IMM CD and the Mid-Am T-bill.

The IMM T-bill contract represents a promise to buy (or sell) $1 million in 13-week U.S. Treasury bills during a three day period in either March, June, September or December, depending upon the month specified by the contract. It is the most heavily traded of the three to be considered here, with an estimated volume of 8,790 contracts on 5/30/85. This relatively large volume provides substantial liquidity for hedgers and speculators, making it less likely for them to get "stuck" in any particular position.

The IMM CD contract represents a promise to buy (or sell) a $1 million Domestic "no-name" Certificate of Deposit with a 3-month maturity.[1] The delivery must occur between the 16th and the last day of the trading month. The CD contract was designed with a larger delivery period than the one for T-bill futures in order to increase the amount of deliverable CDs. Since the CD contract is based on bank CDs, rather than government securities, it is possible that its price movements match the rate changes of CDs or MMCs better than the T-bill contract, making it a better hedging tool. However, the CD's volume is much lower than the T-bill's (estimated volume of 425 contracts on 4/30/85), so it does not provide as much liquidity to investors. Therefore, the hedger must choose between liquidity and hedging efficiency.

The Mid-Am T-bill contract represents a promise to buy or sell $500,000 in 13-week T-bills. It is based on the IMM T-bill contract, traded in the same months, and its price is based on the same index. The smaller size if this contracts provides an opportunity for smaller institutions to hedge. Unfortunately, its trading volume is even lower

---

[1] "No-name" CDs refer to those CDs coming from the largest domestic banks. These CDs are generally of homogeneously high quality, so the investor is indifferent as to which bank is the issuer (Overdahl, 1984, p. 8).

than the IMM CD contract's (estimated at 130 contracts on 5/30/85). Thus, many institutions may shy away from using the Mid-Am contract because they are concerned about liquidity.

This study will concentrate on cross-hedging possibilities between 6 and 3-month MMCs and T-bill futures. T-bill futures were chosen because the large volume traded in the IMM T-bill contract provides the most liquidity for the hedger. The effects that liquidity has on the success rate of the hedges will not be tested, so the instrument which offers the greatest liquidity was chosen. Also, the results using the IMM T-bill contract could be easily translated to the case of a cross-hedge using Mid-Am T-bill "Minis", since the Mid-Am contract forms a secondary market based on the IMM contract. Although the current trading volume in the Mid-Am contract is low, its smaller size might make it more attractive to small banks in the future, possibly causing volume to increase to a point where liquidity no longer is a factor.

Because of the lack of time series data available on MMC rates, CD rates will be used in the empirical analysis of this study. MMCs are basically smaller versions of the CDs, so they tend to follow the rate change of their larger cousins. Thus, the substitution should not radically affect the results of this analysis.

Pricing specifications

Cash T-bills are priced on a discount basis; the purchaser of a $1 million T-bill pays $1 million minus a discount for the bill at the time of the purchase and receives $1 million for it at maturity. T-bill yields are quoted as a 360-day (annualized) discount rate yield, based on the discount from the face amount at purchase.

Annualized Discount Rate Yield = [Discount/Face Value] X [360/Days to Maturity]

The prices of the T-bill contract at the IMM are based on a simple index equal to 100 minus the discount rate yield.

IMM T-bill Futures Index = 100 - Annualized Discount Rate Yield

For example, if the annualized discount rate yield equals 8.25%, then the futures price would be 91.75 (=100-8.25).

Cash CDs are quoted on a bank add-on basis rather than a discount basis; the purchaser of a $1 million CD pays at the outset and receives $1 million plus interest when the CD matures. Market quotes of CD rates are based on a 365-day year bond equivalent yield calculation.

Interest Rate Futures Hedging

A hedge in interest rate futures offers protection against sudden, unexpected price changes in financial instruments resulting from volatile interest rates. Individuals, banks and other financial intermediaries can conceivably benefit from a successful hedging strategy.

Those planning to purchase a financial instrument at a future date can protect themselves from an unexpected drop in interest rates (thus an unexpected increase in the price of the instrument) by purchasing interest rate futures. This activity is similar to a long hedge in the commodity markets. Just as a future purchaser of a commodity (say a grain processor planning to purchase corn) trades away price risk in order to "lock in" a future price, the investor buys interest rate futures in order to lock in current rates and trades away interest rate risk to guarantee a return on his/her investment.

Consider an investor who expects to receive $1 million three months hence and plans to invest that amount in U.S. Treasury Bonds. If s/he suspects that interest rate are at their peak, s/he can may want to buy 10 each of $100,000 CBOT T-bond futures. (Working through a clearing house, s/he does not have to pay the full $1,000,000, only a portion to cover the maximum potential loss for the next day.) In three months, s/he will sell the futures and purchase the bonds on the cash (spot) market. If rates fall (prices rise), the profit s/he earned on the futures will reflect the increased return s/he would have experienced had s/he been able to take a cash position right away. If rates rise (prices fall), the loss on the futures market will reflect the loss of profit s/he would have experienced had s/he been able to invest right away.

Those planning to issue fixed income securities can protect their holding through the sale of futures. This activity is comparable to taking a short position in the commodity futures markets. Just as a grain or livestock producer sells futures in order to lock in the current selling price, a bank or other financial intermediary can sell interest rate futures to lock in interest rates. The commodities hedger trades away price risk to guarantee his return; the financial hedger trades away interest rate risk to guarantee funding costs.

Consider a bank planning to issue $10 million in CDs, three months from now. If it expects that rates will increase before that time, it may want to sell 10 CD contracts, each with a face value of $1 million. In three months, it will buy back the CD futures and sell the CDs in the cash market. If CD rates rise (prices fall), the profit it earned on the short sale in the futures market will reflect the lower funding cost the bank would have experienced had it been able to offer the CDs at the lower rates of three months back. If rates fall (prices rise), the loss on the futures market reflects the increased cost of funding the bank would have faced had it been able to offer the CDs at the lower rates of three months ago.

Basis risk

A critical assumption that has been made here is that cash prices and futures prices move together identically. In reality, they tend to move in the same direction in only a roughly parallel pattern. The arithmetic difference between the cash price and the futures price is called the basis. Changes in the basis tend to be much smaller than either cash or futures price movements. By placing a hedge, the individual is trading away price or interest rate risk for (a much smaller) basis risk. The basis in financial futures is defined differently than it is for commodity futures.

For commodity futures, the basis is defined as the futures price minus the current price, whereas for interest rate futures the basis is generally defined as the current price minus the futures price. Futures prices on commodities tend to be higher than the spot prices, due to (generally positive) inflationary expectations and the fact that it costs money to hold a commodity (storage costs, for example). With financial futures, the futures price tends to be lower than the current spot price (although they are sometimes higher). There are no storage costs incurred from holding a large quantity of T-bonds or T-bills, as there are from holding a carload of grain. Actually, due to the time value of money, a financial instrument earns interest, either explicitly or implicitly. This puts downward pressure on the futures price, relative to the current price. Rising interest rate expectations (discounted intrument prices are expected to drop) put downward pressure on futures prices, relative to the current price. Falling interest rate expectations (discounted instrument prices are expected to rise) put upward pressure on futures prices. Therefore, interest rate expectations may either reinforce or contradict the effect the time value of money has on the basis.

For money market instruments, such as T-bills and CDs, the basis has a natural progression towards zero as the contract nears maturity. Cash money market instruments have changing maturities; if they have a 91-day maturity one day, they have a 90-day maturity the next. This affects their prices, which are directly related to the time to maturity. Futures have a fixed maturity as long as they are held - 91 days for T-bills and 3-months for CDs. As a futures contract approaches its delivery date, its maturity becomes more like the maturity of the cash market instrument on which it is based. Due to arbitraging opportunities which would arise, the spot and futures prices should converge, moving the basis towards zero.

Cross-hedging

Not all financial instruments have a matching futures contract with which to hedge. Also, some contracts (particularly the newer ones) do not have enough volume to allow easy movement in and out of a position, thus making the hedge riskier. Given these circumstances, individuals or institutions may want to set up a cross-hedge with a different, but related, futures contract to hedge their cash positions. They should be aware that the cash and futures prices are usually less correlated for a cross-hedge than they are for a standard hedge, causing the basis to be more volatile and making the basis risk greater. The basis should be watched carefully when a cross-hedge is in place.

The choice of the futures contract to be used in the cross-hedge (as well as whether or not to undertake one) involves careful examination of the basis relationship between the cash instrument and the potential futures contract. Powers and Vogel (1984) named four factors to be considered in a basis relationship. They are:

1) Credit worthiness. If the credit rating of the cash instrument deviates from that of the futures contract, the correlation of the price movements will be adversely affected.
2) Maturity. The closer the two instruments are in maturity, the more they reflect the same time-value judgements.
3) Liquidity. The markets for both instruments should be relatively liquid, otherwise market factors other than the level of interest rates will affect their prices and the basis will be subject to wider fluctuations.

4) Supply and demand factors. Limited or intermittent supply and demand may cause the price of the instruments to fluctuate, increasing basis variations.

(Powers and Vogel, 1984, pp. 186-187).

Because the price movements of the cash instrument are not identical to those of the futures instrument, simply matching the total dollar amount of futures to be traded with the cash position may not provide an optimal hedge. An optimal hedge ratio for cross-hedging two distinctly different instruments was determined by Senchack and Easterwood (1983) and Overdahl (1984) when they looked at cross-hedging CDs with T-bill futures. They did this by comparing changes in the futures rate with changes in the implied forward spot rate. This procedure will be explained in more detail in Chapter 3.

In the search for futures to use in a cross-hedge with 3-month or 6-month MMCs, CD futures and T-bill futures are the prime candidates. Of the two, CD futures more closely match MMCs in terms of credit worthiness and supply and demand factors. Both CD and T-bill futures match maturities with 3-month MMCs and are one-half the maturity of 6-month MMCs (still comparatively close). T-bill futures were chosen over CD futures for this study because their liquidity was greater.

Hedging Strategies for an Agricultural Bank

When a bank decides to use futures to hedge its exposure to interest rate risk, it must choose between two different types of hedges, short hedges and long hedges. With a short hedge, the bank is protected from the risk of rising interest rates. For example, a bank planning to issue a liability three months hence faces the risk of interest rates rising before that time, resulting in higher liability costs. By selling futures on the same (or related) instrument now, the bank will be able to hedge against a rate increase. If interest rates do indeed rise, the gain in the futures market will offset the loss in the cash market. With a long hedge, the bank hedges the risk of falling interest rates. For example, a bank planning to invest $1 million three months hence faces the risk of rates falling before that time, resulting in a diminished return on that investment. By buying futures, the bank can lock in current rates and hedge against that risk.

A specific hedging strategy that might be used by an agricultural bank would be to cross-hedge 6-month or 3-month MMCs with T-bill futures. Consider a bank planning to issue loans ranging anywhere from six months to two years. This bank probably has a limited market for funds, making it difficult to attract liabilities with maturities similar to these loans. Furthermore, lower short-term liability rates provide a way for this bank to widen its profit margin. Unfortunately, funding the longer-term loans with short-term liabilities, such as 6-month or 3-month MMCs, would leave the bank exposed to interest rate risk. By cross-hedging the MMCs with futures, such as T-bills, the bank could lock in current MMC rates and reduce its exposure to interest rate risk.

Macro vs. micro hedging

When establishing a hedging strategy, Drabenstott and McDonley (1984) recommend that the bank first look at its exposure to interest rate risk from a "macro" perspective and then proceed to a "micro" perspective. Macro-hedges reduce, or eliminate, the entire bank's exposure to interest rate risk, whereas micro-hedges are hedges of specific assets or liabilities. The danger of micro-hedging is that it leaves open the possibility of placing a "double hedge." An example of a double hedge would be the situation in which a liability already matched by an asset is hedged so that its rate is locked in at the current level. If the rates go down, the asset rate drops, but the liability rate remains at the current level. In this case the hedge increases, rather than reduces, the bank's risk exposure. Taking a macro-perspective will alert the bank of a liability/asset match-up and prevent the formation of a double hedge.

Upon taking a macro-perspective, the bank will probably find that it needs to place fewer hedges than it thought necessary under the strictly micro-perspective. Thus, its transaction costs will be reduced. After the bank determines its risk exposure and identifies the assets and liabilities to be hedged, it still has to deal with specific groups of assets and liabilities. In this sense, the hedge strategy takes on a "micro" perspective.

One drawback attributed to macro-hedging is the expense of gathering all the information on the bank's interest rate risk exposure. A bank might think it is easier to let each of its departments handle its own risk exposure separately. Kolb, Timme and Gay (1984) considered this problem, but still concluded that a macro-view is more efficient than individual micro-hedges. Furthermore, a small bank would probably have lower information-gathering costs than a large one, implying that it would be even easier for a small bank to implement a macro-hedge. Drabenstott and McDonley (1984) recommend using sensitivity analysis to determine their interest rate exposure for taking a "macro" perspective.

Selective hedging

If the bank has reasonable expectations that interest rates will move in its favor, it may be willing to accept some degree of risk exposure. Thus, it may decide that only part (or perhaps none) of the exposure to interest rate risk should be hedged. Clearly, this is a decision of whether or not to reduce risk, not how to reduce risk. In this study, an attempt will be made at designing a "selective hedging" strategy, in which a bank bases its decisions of whether or not to hedge on its expectations of interest rates.

CHAPTER III. THEORETICAL DEVELOPMENT OF THE MODEL

Chapter III explains the theoretical material needed for the analysis in this study. The first section covers previous studies of hedging efficiency and optimal hedge ratios. The second section outlines the analysis to be used in the empirical section of this study.

Previous Studies of Hedging Performance

The earliest studies of the hedging performance of the financial futures markets were direct applications of the techniques developed for the commodity futures markets by Johnson (1960), Stein (1961) and others. Ederington (1979), Franckle (1980) and Cicchetti, Dale and Vignola (1981) looked at hedges of currently held cash positions in financial futures, just as Johnson and the others had looked at hedges of cash positions in the commodity markets. Eventually, differences between hedging in the financial futures markets and hedging in the commodity futures markets became more clearly defined as differences between the nature of commodity futures and financial futures were stressed. Franckle and Senchack (1982) made the claim that a different type of hedge, called an anticipatory hedge, was relevant to financial futures. With an anticipatory hedge the position being hedged has not yet been taken, but it is expected to be taken in the future. Along with this new type of hedge, a new approach to hedging theory was taken by Senchack and Easterwood (1983), Overdahl (1984) and others. In this section, we will examine these developments of hedging performance theory for financial futures.

Cash hedging

We begin by looking at traditional hedging theory. The traditional, naive hedge requires that a position be taken in the futures market equal in magnitude and opposite in direction to the spot, or cash, position. For example, let P_s^1 and P_s^2 be the spot or cash prices at times t_1 and t_2, respectively. The gain or loss on the unhedged position, U, of X units is $X[P_s^2 - P_s^1]$. Letting P_f^1 and P_f^2 represent the futures prices at times t_1 and t_2, the gain or loss in the hedged position, H, of X units is $X\{[P_s^2 - P_s^1] - [P_f^2 - P_f^1]\}$. Traditional theory argues that since the spot and futures prices generally move together, then Var(H) < Var(U), thereby reducing risk (Ederington (1979), p. 159).

Portfolio theory, unlike traditional hedging theory, allows hedgers to hold both hedged and unhedged stocks. Using previous studies of portfolio theory in commodity futures by Johnson (1960) and Stein (1961), Ederington applied it to financial futures. In this model, Ederington assumed that cash market holdings were being hedged as if they were storable commodities. Letting U represent the return on an unhedged position,

$$(3.1)\quad E(U) = X_s E[P_s^2 - P_s^1]$$

$$(3.2)\quad Var(U) = X_s^2 \sigma_s^2$$

Let R represent the return on a porfolio which includes both spot market holdings and futures market holdings X_f:

$$(3.3)\quad E(R) = X_s E[P_s^2 - P_s^1] + X_f E[P_f^2 - P_f^1] - K(X_f)$$

$$(3.4)\quad Var(R) = X_s^2 \sigma_s^2 + X_f^2 \sigma_f^2 + 2X_s X_f \sigma_{sf}$$

where $K(X_f)$ represents brokerage and other transaction costs and σ_s^2, σ_f^2,

$_{sf}$ represent the subjective variances and the covariance of the possible price changes from time t_1 to t_2.

Let $b = -X_f/X_s$ represent the proportion of the spot position which is hedged, known as the hedge ratio. Since X_f and X_s usually have opposite signs, b is usually positive. Inserting b into (3.3) and (3.4), we get

$$(3.5)\quad Var(R) = X_s^2[\ {}_s^2 + b\ {}_f^2 - 2b\ {}_{sf}]$$

and

$$(3.6)\quad E(R) = X_s[E(P_s^2 - P_s^1) - bE(P_f^2 - P_f^1)] - K(X_x,b)$$

$$= X_s[(1-b)E(P_s^2 - P_s^1) + bE(P_s^2 - P_s^1) - bE(P_f^2 - P_f^1)]$$

$$- K(X_f,b)$$

Or, letting $E(\ B) = E[P_f^2 - P_s^2 - (P_f^1 - P_s^1)]$ represent the expected change in the basis,

$$(3.7)\quad E(R) = X_s[(1-b)E(S) - bE(\ B)] - K(X_f,b)$$

where $E(S) = E(P_s^2 - P_s^1)$ is the expected price change on one unit of the spot commodity. If $E(\ B) = 0$, then the expected gain or loss is reduced as b approaches one. Holding X_s constant,

$$(3.8)\quad Var(R)/\ b = X_s^2\ [2b\ {}_f^2 - 2\ {}_{sf}]$$

so the risk minimizing b is

$$(3.9)\quad b^* = {}_{sf}/\ {}_f^2$$

Also,

$$(3.10)\quad E(R)/\ b = -X_s[E(\ B) - E(S)] - \ K(X_f,b)/\ b$$

Ederington compared the risk on an unhedged position with the minimum risk obtained on a portfolio containing both spot and futures holdings. He used the percent reduction in the variance of the unhedged position as a measure of hedging performance.

(3.11) $e = 1 - Var(R^*)/Var(U)$

where $Var(R^*)$ denotes the minimum variance on a portfolio containing security futures. Subsitituting equation (3.9) into equation (3.5) yields

(3.12) $Var(R^*) = X_s^2[\ {}^2_s + \ {}^2_{sf}/\ {}^2_f - 2\ {}^2_{sf}/\ {}^2_f]$

$= X_s^2[\ {}^2_s - \ {}^2_{sf}/\ {}^2_f]$

Consequently,

(3.13) $e = \ {}^2_{sf}/\ {}^2_f = \ {}^2$

where ^{2} is the population coefficient of determination between the change in the cash price and the change in the futures price. He tested the effectiveness of hedges of cash holdings by estimating ^{2} using the coefficient of determination, r^2, from the following equation:

(3.14) $P_f^2 - P_f^1 = \quad + \quad (P_s^2 - P_s^1) + u$

The r^2 value gives the percentage risk reduction of the hedged position over the unhedged position. The risk-minimizing b^* (the optimal hedge ratio) is indicated by the inverse of the estimated value for .

Ederington (1979) tested the effectiveness of two-week and four-week hedges of GNMA and T-bill holdings. He found the GNMA hedge to be reasonably effective, with r^2 values of 0.664 for a two-week hedge and 0.785 for a four-week hedge in the nearby contracts. These numbers suggested that a two-week hedge in the current GNMA contract reduced risk by approximately 66.4 percent, while a four-week hedge reduced risk by about 78.5 percent. He also tried contracts further into the future and got similar results. His results for the hedge in T-bills were not nearly as good. In the two-week hedge, the nearby contract had an r^2 value of

0.272. (As a point of comparison, the r^2 values for a two-week hedge in the nearby contract of Corn and Wheat were 0.898 and 0.649, respectively.)

In a follow-up article, Charles Franckle (1980) pointed out that Ederington used Friday closing prices for T-bill futures and weekly averages for the cash price data. He contended that these weekly averages tended to "mask" much of the relevent price changes (Franckle, 1980, p. 1274). By matching Friday to Friday changes in futures prices with Friday to Friday changes in the bid price of 90 day T-bills, Franckle got an r^2 value of 0.679, comparing favorably with the GNMA and Corn markets.

Later, Paul Cicchetti, Charles Dale and Anthony J. Vignola (1981) were able to improve on Ederington's and Franckle's findings by focusing on interest rate changes, rather than price changes. They pointed out that T-bills are discount instruments which do not have coupon payments and do not bear interest. Thus, if spot interest rates remain constant, the cash price of a T-bill will increase because of the decrease in remaining term to maturity. On the other hand, if futures interest rates remain constant, the prices of the futures contracts will remain constant. A hedger wants to protect against instantaneous price changes other than those caused by a change in the term to maturity (Cicchetti et al., 1981, p. 380). By using interest rate changes instead of price changes to estimate hedging effectiveness, they were able to take the constant yield accumulation out of the price of a Treasury bill (Cicchetti et al., 1981, p. 383). The results Cicchetti et al. obtained from testing this model gave an r^2 value of 0.755 for a two-week hedge and 0.833 for a four-week hedge in the nearby contract.

Anticipatory hedging

In the studies conducted by Ederington and the others, currently held cash positions were hedged. As Franckle and Senchack (1982), Senchack and Easterwood (1983), Overdahl (1984) and others have observed, this approach is not appropriate for financial futures. Financial instruments, unlike many agricultural commodities, are not storable goods; their maturity (and value) change from one day to the next. A 91-day T-bill today becomes a 90-day T-bill tomorrow. This makes it difficult to hedge a currently held cash position in financial instruments. Over time, the instrument purchased or issued in the cash market becomes less and less like the instrument in the futures market, causing their rate movements to not correlate well.[2]

Franckle and Senchack (1982) and the others have described a different type of hedge to be used with financial futures: the anticipatory hedge. In an anticipatory hedge, a cash position not yet taken, but expected to be taken in the future, is hedged in the futures market. A storable commodity is not needed for this type of hedge. Since the financial instrument is not being held, it does not have to maintain its value for the life of the hedge. Thus, an anticipatory hedge can be

---

[2] Ederington's study (and the others that followed) involved such short-term hedges that changing maturity may not have been as much of a factor as it would have been if longer-term hedges had been examined.

easily applied to financial futures, particularly T-bill and CD futures. An example of an anticipatory hedge would be if a bank, planning to offer CDs or MMCs three months hence, wants to hedge against an increase in rates. The position being hedged is an anticipated position, rather than a currently held one.

With a cash hedge of a storable commodity, the cash position has already been taken when the hedge is placed. The individual placing the hedge does so with the intention of locking in the current price. Thus, the current price becomes the target. The purpose of the hedge is to provide protection against unexpected price changes during the life of the hedge. In an anticipatory hedge in financial futures, the cash position will not be undertaken until the end of the hedge. The target rate for the anticipatory hedge is not the current spot rate, but rather the rate the hedger expects to pay at the end of the hedge. Remember, hedging provides protection against unexpected rate changes only.

It is important to consider the shape of the yield curve when analyzing financial futures hedging. If the yield curve is flat, then rates are not expected to change during the time the hedge is in place. In this case, the target rate is the current spot rate, since the current spot rate is expected to prevail at the time the hedge is lifted. In most cases, however, the yield curve is positively or negatively sloped. A positive yield curve indicates that the market expects rates to increase, while a negatively sloped yield curve indicates just the opposite. Given these expected changes, which are imbedded in the term structure of the rates, the current spot rate becomes a biased estimator of the target rate. On the other hand, an implied forward rate which takes into account the expected rate changes that are imbedded in the term structure would be the correct target for an anticipatory hedge.

The following formula was used by Senchack and Easterwood to calculate the implied forward rates for CDs.

$$(3.15) \quad {}_{n-t}r_t = [nr_n - (n-t)r_{n-t}]/t$$

where ${}_{n-t}r_t$ is the estimated implied t-month spot rate at the time of the hedge's placement; n-t months is the length of the hedge period; and r_n and r_{n-t} are the observed CD cash rates appropriate for the estimation of the implied rate. To estimate a 3-month implied rate 3 months from now, a 3-month and a 6-month CD cash rate was used, i.e., n=6 and t=3 (Senchack and Easterwood, 1983, p. 433-434).

Selective Hedging

Just as hedging reduces the risk of adverse price or interest rate movements, it also reduces the likelihood of gains being made from favorable turns in the market. If the institution placing the hedge is able to forecast market turns with some degree of accuracy, then it may want to use a selective hedging strategy. Under this strategy, the institution will hedge if it expects the cash spot market to make an unfavorable move, and it will not hedge if it is fairly certain that the spot market will move in its favor.

In this study, we will look at how an agricultural bank will fare if it follows a selective hedging strategy for managing its MMCs. Our hypothetical agricultural bank will base its strategy on some forecast of interest rates. If the bank expects rates to increase, it will hedge; if it expects rates to decrease, it will choose not hedge. We want to know whether the bank, by following this strategy, can significantly reduce its rates without exposing itself to additional interest rate risk.

Reducing MMC rates

We can start by asking whether an agricultural bank, following the selective hedging strategy, is able to lower its MMC rates from what they would be if it followed either a simple "always hedge" or "never hedge" plan. In order to determine whether the bank would have observed lower rates by following this strategy, two new statistics are created:

(3.16) $RU_t = R_t - U_t$

(3.17) $RH_t = R_t - H_t$

where U_t = MMC rate an unhedged bank pays at time t

H_t = MMC rate a hedged bank pays at time t

R_t = MMC rate a bank pays at time t if it follows selective hedging strategy.

A mean RU_t significantly less than zero indicates that the bank following the decision model pays lower MMC rates on the average than it would have had it not hedged at all. A mean RH_t significantly less than zero indicates that the bank following the decision model pays lower MMC rates on the average than it would have had it hedged all the time.

Preserving risk reduction

Suppose that the bank can (on the average) reduce the level of MMC rates it pays. Can it also preserve the reduced interest rate risk that it would have gained by hedging all of the time? In order to observe interest rate risk, it is necessary to look at the standard error of the difference between the target rate (the implied forward rate) and the actual, effective rate paid by the bank. A high standard error would indicate a lot of variation in the difference, hence higher risk. A low standard error would indicate little variation and less risk.

In comparisons between the "never hedge" and "always hedge" cases, the "always hedge" case should indicate less risk. Let UP_t refer to the unhedged position and HP_t refer to the hedged position.

$$UP_t = MMC^*_{t-n} - MMC_t \tag{3.18}$$

$$HP_t = MMC^*_{t-n} - MMC_t + FR_t - FR_{t-n} - 0.0004 \tag{3.19}$$

where MMC^*_{t-n} = the implied forward rate at the beginning of the hedge

MMC_t = the spot rate at the end of the hedge

FR_{t-n} = the futures rate at the beginning of the hedge

FR_t = the futures rate at the end of the hedge.

The 0.0004 subtracted from HP_t refers to a round trip transaction cost of about four basis points. UP_t is the difference between the implied forward rate (the target rate) at time t-n and the rate the unhedged bank pays at time t, while HP_t is the difference between the implied forward rate at time t-n and the effective rate the hedged bank pays at time t. The standard errors of UP_t and HP_t indicate the relative deviations from the target rate for the unhedged and hedged positions, thus indicating the level of interest rate risk associated with each position. UP_t is expected to have a higher standard error than HP_t.

When comparing the risk from following a selective hedging policy with risk from following the "never hedge" and "always hedge" plans, we would expect that the risk for the selective hedge would be somewhere between the two extremes. In the selective hedge case, rates are sometimes hedged (risk is lowered) and sometimes not (risk remains high). The selective hedge position would be represented by the difference between the target rate and the rate resulting from using the decision rules:

$$(3.20)\quad RP_t = MMC^*_{t-n} - R_t$$

The purpose of the selective hedging policy is to allow the bank to reduce the risk of rates increasing while taking advantage of the situations when rates are decreasing. Therefore, it is acceptable for the bank (even preferable) to have a high standard error when rates are lower than expected. The bank would prefer to maintain a low standard error when rates are higher than expected. By dividing the observations into two groups, one where the actual rates are lower than the target rates ($RP_t > 0$) and one where the actual rates are higher than the target rates ($RP_t < 0$), we can examine the risk associated with each case.

CHAPTER IV. EMPIRICAL ANALYSIS AND RESULTS

The empirical analysis in this study consists of an examination of how a selective hedging strategy would affect an agricultural bank's effective MMC rates and its exposure to interest rate risk. Hedges of 3-month and 6-month MMCs are considered in this model.

The Hedge Ratio

The naive hedge ratio of 1, rather than an optimal hedge ratio (defined in Chapter III), is used throughout this study. Optimal hedge ratios are not used because those determined in previous studies were close enough to one to make them impractical for use by agricultural banks. The ratios determined by Overdahl (1984) for cross-hedges between CDs and T-bill futures ranged between 0.84 and 1.01.[3] Since fractions of futures contracts cannot be traded, some quantity of contracts greater than one would have to be bought or sold in order to use the optimal hedge ratio. Take, for example, the optimal hedge ratio of 0.84. A hedger would have to plan to sell at least 4 contracts under the naive hedge in order to use the optimal hedge ratio:

$$4 \text{ contracts (naive hedge)} \times 0.84 = 3.36 \text{ contracts (optimal hedge)} \approx 3 \text{ contracts}$$

Four contracts in T-bill futures represent \$2 million at the Mid-Am and \$4 million at the IMM. Therefore, an agricultural bank would have to plan to

---

[3] Overdahl (1984) determined optimal hedge ratios of 1.01, 1.00 and 0.84 for cross hedges of 3-month CDs and T-bill futures placed 3, 4 and 5 months prior to the contract month, respectively (Overdahl, 1984, p. 50).

offer at least $2 million in MMCs at one particular time in order to use an optimal hedge ratio. It is doubtful that a typical agricultural bank would feel the need to hedge a position that large at any one particular time. On an added note, Senchack and Easterwood (1983) found the benefits of an optimal hedge over the naive hedge to be minimal for cross-hedges between T-bill futures and 3-month and 6-month CDs (Senchack and Easterwood, 1983, p. 438).

Data

Cross-hedges of 3-month and 6-month MMCs with T-bill futures are examined for this study. CD rates are used in place of MMC rates because CD rate data is more readily available. The similarities in rate movements of CDs and MMCs supports this substitution. The T-bill rates are secondary market rates obtained from the Federal Reserve Bulletin, Table 1.35 (or 1.36). The CD rates are weekly averages of daily secondary market rates obtained from the Bank of America. The T-bill futures prices are weekly averages of daily data obtained from tapes provided by the International Monetary Market. Weekly averages from April, 1981 to December, 1984 are used for this model.

Since the CD rates are quoted on a bond equivalent basis, they have to be converted to a bank discount yield in order to coincide with the futures data. The following transformation, as defined by Overdahl (1984), is used to convert the CD rates:

(4.1) Annualized Spot Discount Rate = $360i/[365 + it_{sm}]$

where i = the bond equivalent yield

t_{sm} = the time from settlement to maturity (in days).

In this model, 13-week and 26-week hedges are examined. The target rates (the rate to be hedged) are the 3-month and 6-month implied forward spot rates, which are based on the formula described by Senchack and Easterwood (1983).

(4.2a) $_{3}MMC^{*}_{3,t} = [6\ MMC_{6,t} - 3\ MMC_{3,t}]/3$

(4.2b) $_{6}MMC^{*}_{6,t} = [12\ MMC_{12,t} - 6\ MMC_{6,t}]/6$

where $MMC_{3,t}$ = three-month CD spot rate at time t.

$MMC_{6,t}$ = six-month CD spot rate at time t

$MMC_{12,t}$ = one-year CD spot rate at time t.

T-bill futures are used to hedge future offerings of three-month MMCs.

The hypothesis of this model is founded on the assumption that banks base their decisions of whether or not to hedge on a forecast of future interest rates. If they expect rates to increase, they hedge; if they expect rates to decrease, they don't hedge. Two different sets of forecast data are tested in the model. One set is simply the T-bill futures rates on the deferred contracts. Assuming that the rates on the deferred contracts provide the market's predictions of which direction the rates will move in the next three or six months, the bank will hedge if the deferred contract rate is greater than the implied forward rate for 90-day T-bills, and it will not hedge if the opposite is the case. The other set of predictions used in this model consists of quarterly forecasts, provided by the American Statistical Institute (ASI), of 90-day T-bill rates. If the ASI forecast is greater than the implied forward rate for 90-day T-bills, then the bank will hedge; if the ASI forecast is less than the implied foreward rate for 90-day T-bills, it will choose not to hedge.

Accuracy of the Forecasts

When using a forecast of any kind, allowances must be made for margins of error. Therefore, it becomes necessary to test the success of the forecasts. For both forecasts used in this model, a new statistic, POWER, is formulated by subtracting the predicted changes in T-bill rates from the actual changes in MMC rates:

$$(4.3)\quad POWERA_i = (MMC_{i,t} - {}_iMMC^*_{i,t-i}) - (FR_{t-i} - {}_iTB^*_{i,t-i})$$

$$(4.4)\quad POWERB_i = (MMC_{i,t} - {}_iMMC^*_{i,t-i}) - (ASI_{i,t-i} - {}_iTB^*_{i,t-i})$$

where $i = 3, 6$

$MMC_{i,t}$ = bank discount equivalent of i-month CD rates at time t, the end of the hedge

${}_iMMC^*_{i,t-i}$ = the estimated implied i-month CD spot rate at time t-i, the beginning of the hedge

${}_iTB^*_{i,t-i}$ = the estimated implied i-month T-bill spot rate at time t-i

$FR_{i,t-i}$ = the T-bill futures rate of the i-month deferred contract at time t-i

$ASI_{i,t-i}$ = the ASI prediction for time t, made at time t-i.

POWERA and POWERB indicate the strength of the forecasts in predicting MMC rates over the hedging period. A POWER statistic equal to zero would imply that the predicted change in T-bill rates would exactly equal the actual change in MMC rates. By itself, a mean of POWER different from zero would not pose a problem with the predictions. The banks can simply adjust their decisions to reflect the error. A large standard error, however, would weaken the strength of the predictions.

Each POWER statistic is determined two different ways. One way is to simply group all the observations together. The other way is to divide the data into three groups:

Group 1 : March, June, September and December;

Group 2 : February, May, August and November;

Group 3 : June, April, July and October.

Group 1 consists of observations made during the futures contract months, so that predictions based on futures prices will be based on contracts due three month hence. Those months are each the third month of their particular quarter, so that the ASI predictions in this group will all pertain to the last month of the quarter. Likewise, Group 2 consists of observations made one month previous to futures contract months and during the second month of the quarter; and Group 3 consists of observations two months prior to the contract months and during the first month of the quarter. The purpose of this grouping according to months is to try to take into account differences in the standard error caused by the fact that, in both cases, essentially quarterly data is used for weekly predictions. The standard error would be likely to change over time within the quarter, and the separate groupings is an attempt to arrange the observations according to the time at which they occurred during the quarter. Of course, using separate groups such as this does mean a reduced number of observations for each, thereby lowering the degrees of freedom.

It would be unrealistic to assume that a bank would estimate POWER once and use the same estimate ad infinitum. It is more likely that it would re-estimate POWER regularly, as more data on interest rate predictions and their actual rates became available. In this model, POWER is re-estimated every quarter, the first estimation occuring after 66 weeks and the last one occuring after 157 weeks. The summary statistics for POWER are given in Tables 4.1-4.8.

Three-month hedges

For the three-month hedges, the standard error of POWERA (futures predictions) is consistently higher than that of POWERB (ASI predictions). This is true for the case when the data for all the months is pooled together (Table 4.1) and the cases when the months are separated into the three groups (Tables 4.2-4.4). For example, in Table 4.1, 1984, 3rd quarter, the standard errors of POWERA and POWERB are 0.00152 and 0.0007, respectively. This suggests that the ASI predictions will do a better job of forecasting MMC rate changes than the futures market will and that they will probably provide better results to a bank following a selective hedge strategy.

The standard errors for the cases when the months are pooled together are usually lower than those for the cases when the months are separated into the three groups. For example, the standard errors of POWERA, 1984, 3rd quarter for the three groups of months are 0.00096, 0.00112, and

Table 4.1. Summary statistics for POWER: 3-month hedge; all months pooled together

	Dates Used		Number of		
	Year	Qtr	Observations	Mean	Standard Error
POWERA	1982	IV	66	0.00522	0.00299
(Futures Predictions)	1983	I	79	-0.00042	0.00290
		II	92	-0.00095	0.00250
		III	105	-0.00060	0.00220
		IV	118	0.00008	0.00197
	1984	I	131	-0.00059	0.00179
		II	144	-0.00043	0.00163
		III	157	0.00044	0.00152
POWERB	1982	IV	66	0.01006	0.00138
(ASI Predictions)	1983	I	79	0.00925	0.00119
	.	II	92	0.00843	0.00105
		III	105	0.00793	0.00094
		IV	118	0.00655	0.00091
	1984	I	131	0.00623	0.00083
		II	144	0.00627	0.00076
		III	157	0.00652	0.00071

Table 4.2. Summary statistics for POWER: 3-month hedge; March, June, September, December only

	Dates Used		Number of		
	Year	Qtr	Observations	Mean	Standard Error
POWERA	1982	IV	22	-0.00159	0.00564
(Futures Predictions)	1983	I	27	-0.00642	0.00505
		II	32	-0.00560	0.00428
		III	37	-0.00434	0.00374
		IV	42	-0.00406	0.00329
	1984	I	47	-0.00388	0.00295
		II	52	-0.00340	0.00267
		III	56	-0.00263	0.00251
POWERB	1982	IV	22	0.00457	0.00188
(ASI Predictions)	1983	I	27	0.00409	0.00155
		II	32	0.00439	0.00133
		III	37	0.00497	0.00117
		IV	42	0.00361	0.00118
	1984	I	47	0.00395	0.00107
		II	52	0.00447	0.00100
		III	56	0.00498	0.00096

Table 4.3. Summary statistics for POWER: 3-month hedge; February, May, August, November only

	Dates Used		Number of		
	Year	Qtr	Observations	Mean	Standard Error
POWERA	1982	IV	20	0.00319	0.00547
(Futures Predictions)	1983	I	24	-0.00161	0.00508
		II	28	-0.00154	0.00434
		III	32	-0.00145	0.00381
		IV	36	0.00002	0.00347
	1984	I	40	-0.00092	0.00315
		II	44	-0.00079	0.00287
		III	49	0.00069	0.00265
POWERB	1982	IV	20	0.00814	0.00235
(ASI Predictions)	1983	I	24	0.00764	0.00198
		II	28	0.00713	0.00172
		III	32	0.00636	0.00155
		IV	36	0.00538	0.00146
	1984	I	40	0.00501	0.00133
		II	44	0.00500	0.00121
		III	49	0.00562	0.00112

Table 4.4. Summary statistics for POWER: 3-month hedge; January, April, July, October only

	Dates Used		Number of		
	Year	Qtr	Observations	Mean	Standard Error
POWERA	1982	IV	24	0.01317	0.00416
(Futures Predictions)	1983	I	28	0.00639	0.00479
		II	32	0.00423	0.00430
		III	36	0.00401	0.00383
		IV	40	0.00448	0.00345
	1984	I	44	0.00324	0.00319
		II	48	0.00312	0.00292
		III	52	0.00351	0.00270
POWERB	1982	IV	24	0.01669	0.00219
(ASI Predictions)	1983	I	28	0.01560	0.00197
		II	32	0.01361	0.00198
		III	36	0.01236	0.00186
		IV	40	0.01071	0.00185
	1984	I	44	0.00977	0.00174
		II	48	0.00940	0.00161
		III	52	0.00903	0.00149

Table 4.5. Summary statistics for POWER: 6-month hedge; all months pooled together

	Dates Used		Number of		
	Year	Qtr	Observations	Mean	Standard Error
POWERA	1982	IV	53	-0.00031	0.00226
(Futures Predictions)	1983	I	66	-0.00844	0.00274
		II	79	-0.01311	0.00261
		III	92	-0.01275	0.00225
		IV	105	-0.01034	0.00208
	1984	I	118	-0.00931	0.00187
		II	131	-0.00914	0.00170
POWERB	1982	IV	53	0.00644	0.00278
(ASI Predictions)	1983	I	66	0.00373	0.00234
		II	79	0.00342	0.00196
		III	92	0.00371	0.00170
		IV	105	0.00496	0.00152
	1984	I	118	0.00442	0.00136
		II	131	0.00467	0.00123

Table 4.6. Summary statistics for POWER: 6-month hedge; March, June, September, December only

	Dates Used		Number of		
	Year	Qtr	Observations	Mean	Standard Error
POWERA	1982	IV	18	-0.00400	0.00374
(Futures Predictions)	1983	I	23	-0.01330	0.00478
		II	28	-0.01687	0.00423
		III	33	-0.01495	0.00368
		IV	38	-0.01249	0.00337
	1984	I	43	-0.01135	0.00301
		II	48	-0.01062	0.00273
POWERB	1982	IV	18	0.00334	0.00506
(ASI Predictions)	1983	I	23	0.00113	0.00406
		II	28	0.00114	0.00333
		III	33	0.00260	0.00289
		IV	38	0.00393	0.00257
	1984	I	43	0.00371	0.00227
		II	48	0.00440	0.00205

Table 4.7. Summary statistics for POWER: 6-month hedge; February, May, August, November only

	Dates Used		Number of		
	Year	Qtr	Observations	Mean	Standard Error
POWERA	1982	IV	16	-0.00596	0.00443
(Futures Predictions)	1983	I	20	-0.01210	0.00451
		II	24	-0.01570	0.00411
		III	28	-0.01515	0.00353
		IV	32	-0.01205	0.00342
	1984	I	36	-0.01021	0.00316
		II	40	-0.01021	0.00285
POWERB	1982	IV	16	0.00134	0.00615
(ASI Predictions)	1983	I	20	-0.00083	0.00499
		II	24	-0.00018	0.00416
		III	28	0.00009	0.00357
		IV	32	0.00212	0.00326
	1984	I	36	0.00188	0.00290
		II	40	0.00223	0.00261

Table 4.8. Summary statistics for POWER: 6-month hedge; January, April, July, October only

	Dates Used		Number of		
	Year	Qtr	Observations	Mean	Standard Error
POWERA	1982	IV	19	0.00796	0.00300
(Futures Predictions)	1983	I	23	-0.00041	0.00462
		II	27	-0.00692	0.00498
		III	31	-0.00823	0.00438
		IV	35	-0.00644	0.00397
	1984	I	39	-0.00623	0.00358
		II	43	-0.00648	0.00325
POWERB	1982	IV	19	0.01367	0.00287
(ASI Predictions)	1983	I	23	0.01029	0.00288
		II	27	0.00898	0.00252
		III	31	0.00816	0.00222
		IV	35	0.00869	0.00198
	1984	I	39	0.00754	0.00186
		II	43	0.00726	0.00169

0.00149, respectively (Tables 4.2, 4.3 and 4.4). This compares with a value of 0.00071 for the pooled case. The higher standard errors for the separated cases may be due to the decreased number of observations which resulted from separating the data. The higher standard errors for the separate groups of months suggest that, for this many observations, the pooled data provides a better estimation of POWER than the separated data. Therefore, separating the data into the three groups is not expected to improve the results of this study.

Six-month hedges

The standard errors for POWERA and POWERB tend to be higher for the 6-month hedges than they are for the 3-month hedges, particularly in the case when all the months are pooled together. For example, in Table 4.5, 1984, 3rd quarter, POWERA and POWERB have standard errors of 0.00170 and 0.00123, respectively. These are higher than the standard errors in the same cases for the three-month hedges. These numbers suggest that the futures market and the ASI do a better job projecting rates over one quarter than they do over two quarters. Therefore, it can be expected that the results from the selective hedging strategy for a 6-month hedge will be inferior to those for a 3-month hedge.

The differences between the standard errors of POWERA and POWERB are not as large, in relative terms, in the 6-month case as they are in the 3-month case. In some cases early in the testing period, the standard error of POWERA is actually less than that of POWERB. This suggests that the ASI predictions do not exhibit as much superiority over the futures predictions in the 6-month case as they do in the 3-month case. Thus, the results using the ASI predictions might be closer to the ones using the futures predictions in the 6-month case than they are in the 3-month case.

As in the case of the 3-month hedges, the standard errors for POWER for 6-month hedges tend to be greater when the months are separated into the three groups than when they are pooled together. Therefore, separating the data into the three groups is not expected to improve the results for the 6-month selective hedging strategy.

Setting Up Decision Rules

By creating confidence intervals around POWER, we can predict, with some degree of accuracy, whether rates will move up or down significantly. The confidence intervals have the form

(4.5) $\underline{X} < \text{POWER} < \bar{X}$.

Letting AC denote "actual change" and PC denote "predicted change," POWER=AC-PC. We can rewrite the interval as

(4.6) $\underline{X} < \text{AC-PC} < \bar{X}$.

Taking the left inequality and rearranging, we get

(4.7) $\underline{X} + \text{PC} < \text{AC}$.

If we assume that $\underline{X}+\text{PC}>0$, then we know that AC>0. Having an actual change greater than zero means that the bank should hedge. Therefore, the bank would hedge if $\underline{X}+\text{PC}>0$, or $\text{PC}>-\underline{X}$. Taking the right inequality and rearranging, we get

(4.8) $\text{AC} < \bar{X} + \text{PC}$.

If $\bar{X}$+PC<0, then AC<0. A negative change in interest rates would tell the bank not to hedge. Therefore, the bank does not hedge if $\bar{X}$+PC<0, or PC<$-\bar{X}$.

Let us assume that a bank is more adverse to having rates increase and not being hedged than it is to having them decrease and being hedged into higher rates. The bank prefers to run the risk of hedging when it should not, rather than not hedging when it should. We can set up a one-sided confidence interval, using only an upper bound to limit the bank's risk of not hedging when it should. The bank follows this decision rule:

If PC < $-\bar{X}$, then don't hedge;

If PC > $-\bar{X}$, then hedge.

For each estimate of POWER, two one-sided confidence intervals are constructed, one with 95% confidence and one with 99% confidence (Tables 4.9-4.16).

Two-sided confidence intervals are also constructed for this model. However, it is not clear what the bank should do if no significant change is predicted, that is, if the predicted change falls between $-\bar{X}$ and $-\underline{X}$. If rates do not change, it should not matter whether banks lock in current rates or not. Hedging does incur transaction costs of about four basis points per round trip, but this cost is minimal. An attempt is made to determine whether there are any significant differences between the decisions to hedge all, half or none of the risk when no significant change is predicted. In this scenario the bank follows this decision rule:

If PC < $-\bar{X}$, then don't hedge;

Table 4.9. Confidence intervals for POWER: 3-month hedge; all months pooled together

Statistic	Dates Used		95% One-Sided	95% Two-Sided		99% One-Sided	99% Two-Sided	
	Year	Qtr	$\bar{x}$	$\underline{x}$	$\bar{x}$	$\bar{x}$	$\underline{x}$	$\bar{x}$
POWERA	1982	IV	0.01014	-0.00064	0.01108	0.01218	-0.00248	0.01292
	1983	I	0.00435	-0.00610	0.00526	0.00623	-0.00789	0.00705
		II	0.00316	-0.00585	0.00395	0.00487	-0.00739	0.00549
		III	0.00302	-0.00491	0.00371	0.00452	-0.00627	0.00507
		IV	0.00332	-0.00378	0.00394	0.00466	-0.00499	0.00515
	1984	I	0.00235	-0.00401	0.00292	0.00358	-0.00520	0.00402
		II	0.00225	-0.00362	0.00276	0.00336	-0.00463	0.00377
		III	0.00294	-0.00254	0.00342	0.00398	-0.00347	0.00435
POWERB	1982	IV	0.01233	0.00736	0.01276	-0.01327	0.00651	0.01361
	1983	I	0.01121	0.00692	0.01158	0.01202	0.00619	0.01231
		II	0.01016	0.00637	0.01049	0.01087	0.00573	0.01113
		III	0.00948	0.00609	0.00977	0.01012	0.00551	0.01035
		IV	0.00805	0.00477	0.00833	0.00867	0.00421	0.00889
	1984	I	0.00760	0.00460	0.00786	0.00816	0.00409	0.00837
		II	0.00752	0.00478	0.00776	0.00804	0.00431	0.00823
		III	0.00769	0.00513	0.00791	0.00817	0.00469	0.00835

Table 4.10. Confidence intervals for POWER: 3-month hedge; March, June, September, December only

Statistic	Dates Used		95% One-Sided	95% Two-Sided		99% One-Sided	99% Two-Sided	
	Year	Qtr	$\bar{x}$	$\underline{x}$	$\bar{x}$	$\bar{x}$	$\underline{x}$	$\bar{x}$
POWERA	1982	IV	0.00812	-0.01332	0.01014	0.01261	-0.01756	0.01438
	1983	I	0.00220	-0.01680	0.00396	0.00610	-0.02045	0.00761
		II	0.00144	-0.01399	0.00279	0.00436	-0.01662	0.00542
		III	0.00181	-0.01167	0.00299	0.00436	-0.01397	0.00529
		IV	0.00135	-0.01051	0.00239	0.00360	-0.01253	0.00441
	1984	I	0.00097	-0.00966	0.00190	0.00298	-0.01148	0.00372
		II	0.00099	-0.00863	0.00183	0.00281	-0.01028	0.00348
		III	0.00150	-0.00755	0.00229	0.00321	-0.00909	0.00383
POWERB	1982	IV	0.00781	0.00066	0.00848	0.00930	-0.00075	0.00989
	1983	I	0.00673	0.00090	0.00728	0.00793	-0.00022	0.00840
		II	0.00658	0.00178	0.00700	0.00748	0.00097	0.00781
		III	0.00689	0.00268	0.00726	0.00769	0.00196	0.00798
		IV	0.00555	0.00130	0.00592	0.00636	0.00057	0.00665
	1984	I	0.00571	0.00185	0.00605	0.00644	0.00119	0.00671
		II	0.00612	0.00251	0.00645	0.00680	0.00190	0.00705
		III	0.00656	0.00310	0.00686	0.00721	0.00251	0.00745

Table 4.11. Confidence intervals for POWER: 3-month hedge; February, May, August, November only

	Dates Used		95% One-Sided	95% Two-Sided		99% One-Sided	99% Two-Sided	
Statistic	Year	Qtr	$\bar{x}$	$\underline{x}$	$\bar{x}$	$\bar{x}$	$\underline{x}$	$\bar{x}$
POWERA	1982	IV	0.01265	-0.00826	0.01464	0.01708	-0.01246	0.01884
	1983	I	0.00710	-0.01212	0.00890	0.01109	-0.01587	0.01265
		II	0.00585	-0.01045	0.00737	0.00919	-0.01357	0.01049
		III	0.00482	-0.00892	0.00602	0.00742	-0.01126	0.00836
		IV	0.00573	-0.00678	0.00682	0.00809	-0.00892	0.00896
	1984	I	0.00426	-0.00709	0.00525	0.00641	-0.00903	0.00719
		II	0.00393	-0.00642	0.00484	0.00589	-0.00818	0.00660
		III	0.00505	-0.00450	0.00588	0.00686	-0.00613	0.00751
POWERB	1982	IV	0.01220	0.00322	0.01306	0.01411	0.00142	0.01486
	1983	I	0.01103	0.00354	0.01174	0.01259	0.00208	0.01320
		II	0.01006	0.00360	0.01066	0.01138	0.00236	0.01190
		III	0.00891	0.00332	0.00940	0.00997	0.00237	0.01035
		IV	0.00778	0.00252	0.00824	0.00878	0.00162	0.00914
	1984	I	0.00720	0.00240	0.00762	0.00810	0.00159	0.00843
		II	0.00699	0.00263	0.00737	0.00782	0.00188	0.00812
		III	0.00746	0.00342	0.00782	0.00823	0.00274	0.00850

Table 4.12. Confidence intervals for POWER: 3-month hedge; January, April, July, October only

Statistic	Dates Used Year	Qtr	95% One-Sided $\bar{x}$	95% Two-Sided $\underline{x}$	95% Two-Sided $\bar{x}$	99% One-Sided $\bar{x}$	99% Two-Sided $\underline{x}$	99% Two-Sided $\bar{x}$
POWERA	1982	IV	0.02030	0.00456	0.02178	0.02357	0.00149	0.02485
	1983	I	0.01454	-0.00343	0.01621	0.01822	-0.00687	0.01965
		II	0.01130	-0.00420	0.01266	0.01424	-0.00772	0.01618
		III	0.01031	-0.00350	0.01152	0.01292	-0.00585	0.01387
		IV	0.01016	-0.02228	0.01124	0.01251	-0.00440	0.01336
	1984	I	0.00849	-0.00301	0.00949	0.01066	-0.00497	0.01145
		II	0.00792	-0.00260	0.00884	0.00991	-0.00440	0.01064
		III	0.00795	-0.00178	0.00880	0.00979	-0.00344	0.01046
POWERB	1982	IV	0.02044	0.01216	0.02122	0.02217	0.01054	0.02284
	1983	I	0.01895	0.01156	0.01964	0.02047	0.01014	0.02106
		II	0.01687	0.00973	0.01749	0.01822	0.00851	0.01871
		III	0.01542	0.00871	0.01601	0.01669	0.00757	0.01715
		IV	0.01375	0.00708	0.01434	0.01501	0.00595	0.01547
	1984	I	0.01263	0.00636	0.01318	0.01382	0.00529	0.01425
		II	0.01205	0.00624	0.01256	0.01315	0.00525	0.01355
		III	0.01148	0.00611	0.01195	0.01250	0.00519	0.01287

Table 4.13. Confidence intervals for POWER: 6-month hedge; all months pooled together

	Dates Used		95% One-Sided	95% Two-Sided		99% One-Sided	99% Two-Sided	
Statistic	Year	Qtr	$\bar{x}$	$\underline{x}$	$\bar{x}$	$\bar{x}$	$\underline{x}$	$\bar{x}$
POWERA	1982	IV	0.00341	-0.00474	0.00412	0.00495	-0.00613	0.00551
	1983	I	-0.00392	-0.01383	-0.00305	-0.00204	-0.01552	-0.00136
		II	-0.00882	-0.01823	-0.00799	-0.00704	-0.01983	-0.00639
		III	-0.00905	-0.01716	-0.00834	-0.00741	-0.01854	-0.00696
		IV	-0.00692	-0.01442	-0.00626	-0.00550	-0.01570	-0.00498
	1984	I	-0.00623	-0.01298	-0.00564	-0.00496	-0.01413	-0.00449
		II	-0.00634	-0.01247	-0.00581	-0.00518	-0.01352	-0.00476
POWERB	1982	IV	0.01101	0.00099	0.01189	0.01291	-0.00072	0.01360
	1983	I	0.00758	-0.00086	0.00832	0.00918	-0.00230	0.00926
		II	0.00664	-0.00042	0.00726	0.00798	-0.00163	0.00847
		III	0.00651	0.00038	0.00704	0.00767	-0.00067	0.00809
		IV	0.00746	0.00198	0.00794	0.00850	0.00105	0.00887
	1984	I	0.00666	0.00175	0.00709	0.00758	0.00092	0.00792
		II	0.00669	0.00226	0.00708	0.00753	0.00150	0.00784

Table 4.14. Confidence intervals for POWER: 6-month hedge; March, June, September, December only

	Dates Used		95% One-Sided	95% Two-Sided		99% One-Sided	99% Two-Sided	
Statistic	Year	Qtr	$\bar{x}$	$\underline{x}$	$\bar{x}$	$\bar{x}$	$\underline{x}$	$\bar{x}$
POWERA	1982	IV	0.00251	-0.01189	0.00389	0.00560	-0.01484	0.00684
	1983	I	-0.00509	-0.02321	-0.00339	-0.00131	-0.02677	0.00017
		II	-0.00967	-0.02555	-0.00819	-0.00641	-0.02859	-0.00515
		III	-0.00890	-0.02117	-0.00873	-0.00639	-0.02443	-0.00547
		IV	-0.00695	-0.01910	-0.00588	-0.00465	-0.02117	-0.00381
	1984	I	-0.00640	-0.01725	-0.00545	-0.00435	-0.01910	-0.00360
		II	-0.00613	-0.01597	-0.00527	-0.00427	-0.01765	-0.00359
POWERB	1982	IV	0.01214	-0.00734	0.01402	0.01633	-0.01132	0.01800
	1983	I	0.00810	-0.00729	0.00955	0.01131	-0.01032	0.01258
		II	0.00681	-0.00569	0.00797	0.00938	-0.00809	0.00447
		III	0.00735	-0.00306	0.00826	0.00933	-0.00484	0.01004
		IV	0.00816	-0.00111	0.00897	0.00991	-0.00269	0.01055
	1984	I	0.00744	-0.00074	0.00816	0.00899	-0.00214	0.00956
		II	0.00777	0.00038	0.00842	0.00917	-0.00088	0.00968

Table 4.15. Confidence intervals for POWER: 6-month hedge; February, May, August, November only

Statistic	Dates Used Year	Qtr	95% One-Sided $\bar{x}$	95% Two-Sided $\underline{x}$	95% Two-Sided $\bar{x}$	99% One-Sided $\bar{x}$	99% Two-Sided $\underline{x}$	99% Two-Sided $\bar{x}$
POWERA	1982	IV	0.00181	-0.01540	0.00348	0.00557	-0.01902	0.00710
	1983	I	-0.00430	-0.02154	-0.00266	-0.00065	-0.02500	0.00080
		II	-0.00866	-0.02420	-0.00720	-0.00543	-0.02724	-0.00416
		III	-0.00914	-0.02239	-0.00791	-0.00642	-0.02493	-0.00537
		IV	-0.00642	-0.01875	-0.00535	-0.00409	-0.02086	-0.00324
	1984	I	-0.00501	-0.01640	-0.00402	-0.00286	-0.01835	-0.00207
		II	-0.00552	-0.01580	-0.00462	-0.00358	-0.01755	-0.00287
POWERB	1982	IV	0.01212	-0.01177	0.01445	0.01734	-0.01678	0.01946
	1983	I	0.00780	-0.01127	0.00961	0.01184	-0.01511	0.01345
		II	0.00695	-0.00879	0.00843	0.01022	-0.01186	0.01150
		III	0.00617	-0.00724	0.00742	0.00892	-0.00980	0.00998
		IV	0.00748	-0.00427	0.00851	0.00971	-0.00627	0.01051
	1984	I	0.00665	-0.00380	0.00756	0.00863	-0.00559	0.00935
		II	0.00652	-0.00289	0.00735	0.00830	-0.00449	0.00895

Table 4.16. Confidence intervals for POWER: 6-month hedge; January, April, July, October only

	Dates Used		95% One-Sided	95% Two-Sided		99% One-Sided	99% Two-Sided	
Statistic	Year	Qtr	$\bar{x}$	$\underline{x}$	$\bar{x}$	$\bar{x}$	$\underline{x}$	$\bar{x}$
POWERA	1982	IV	0.01316	0.00166	0.01426	0.01562	-0.00067	0.01659
	1983	I	0.00752	-0.00999	0.00917	0.01118	-0.01343	0.01261
		II	0.00158	-0.01716	0.00332	0.00543	-0.02076	0.00692
		III	-0.00102	-0.01681	0.00035	0.00196	-0.01951	0.00305
		IV	0.00009	-0.01422	0.00134	0.00280	-0.01666	0.00378
	1984	I	-0.00034	-0.01325	0.00079	0.00210	-0.01545	0.00299
		II	-0.00113	-0.01285	-0.00011	0.00108	-0.01485	0.00189
POWERB	1982	IV	0.01865	0.00764	0.01970	0.02099	0.00541	0.02193
	1983	I	0.01523	0.00432	0.01626	0.01751	0.00217	0.01841
		II	0.01328	0.00380	0.01416	0.01523	0.00198	0.01598
		III	0.01181	0.00381	0.01251	0.01333	0.00244	0.01388
		IV	0.01195	0.00481	0.01257	0.01330	0.00359	0.01379
	1984	I	0.01060	0.00389	0.01119	0.01187	0.00275	0.01233
		II	0.01004	0.00395	0.01057	0.01119	0.00291	0.01161

If $-\bar{X} < PC < -\underline{X}$, then hedge all/half/none of the risk exposure;

If $PC > -\underline{X}$, then hedge all of the risk exposure.

For each estimate of power, two two-sided confidence intervals are also constructed, one with 95% confidence and one with 99% confidence (Tables 4.9-4.16).

Determining and Comparing Results

The purpose of this study is to determine whether banks can reduce their effective MMC rates, on the average, by using any of the decision rules identified. Furthermore, given that they are able to lower their MMC rates, are they able to reduce risk exposure as much as when they hedge all the time?

Rate reduction

In order to determine whether the bank effectively reduces its MMC rates by following any of the selective hedging strategies, RU_t and RH_t (defined in Chapter III) are determined. The summary stastistics for RU_t and RH_t are given in Tables 4.17-4.24.

For RU_t, the decision rules based on the futures market predictions yield significant positive mean values for both the 3-month hedge and the 6-month hedge. This means that, on the average, a bank pays higher MMC rates by following one of these decision rules than it would pay if it did not hedge at all. Some of the decision rules based on the ASI predictions yield significant negative values of RU_t in the 3-month hedge. For example, the decision rules based on the two-sided confidence intervals (CIs) where the position is not hedged if rates are expected to change yield values of -0.00125 for the 95% CI and -0.00137 for the 99% CI

Table 4.17. Summary statistics for RU_t: 3-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		104	0.00328	0.00094
	95% CI, Two-Sided	None	104	0.00167	0.00057
		Half	104	0.00247	0.00067
		All	104	0.00328	0.00094
	99% CI, One-Sided		104	0.00328	0.00094
	99% CI, Two-Sided	None	104	0.00129	0.00039
		Half	104	0.00228	0.00057
		All	104	0.00328	0.00094
ASI Predictions	95% CI, One-Sided		104	-0.00028	0.00059
	95% CI, Two-Sided	None	104	-0.00125	0.00049
		Half	104	-0.00071	0.00052
		All	104	-0.00016	0.00060
	99% CI, One-Sided		104	-0.00007	0.00061
	99% CI, Two-Sided	None	104	-0.00137	0.00047
		Half	104	-0.00066	0.00052
		All	104	0.00005	0.00062

Table 4.18. Summary statistics for RU_t: 3-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		104	0.00328	0.00094
	95% CI, Two-Sided	None	104	0.00120	0.00042
		Half	104	0.00224	0.00058
		All	104	0.00328	0.00094
	99% CI, One-Sided		104	0.00328	0.00094
	99% CI, Two-Sided	None	104	0.00089	0.00035
		Half	104	0.00209	0.00055
		All	104	0.00328	0.00094
ASI Predictions	95% CI, One-Sided		104	-0.00049	0.00058
	95% CI, Two-Sided	None	104	-0.00096	0.00049
		Half	104	-0.00073	0.00051
		All	104	-0.00049	0.00058
	99% CI, One-Sided		104	-0.00014	0.00062
	99% CI, Two-Sided	None	104	-0.00105	0.00048
		Half	104	-0.00051	0.00052
		All	104	0.00003	0.00063

Table 4.19. Summary statistics for RU_t: 6-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		91	0.00402	0.00114
		None	91	0.00075	0.00034
	95% CI, Two-Sided	Half	91	0.00225	0.00066
		All	91	0.00374	0.00121
	99% CI, One-Sided		91	0.00285	0.00128
		None	91	0.00063	0.00032
	99% CI, Two-Sided	Half	91	0.00163	0.00070
		All	91	0.00263	0.00129
ASI Predictions	95% CI, One-Sided		91	-0.00071	0.00091
		None	91	-0.00013	0.00047
	95% CI, Two-Sided	Half	91	-0.00035	0.00062
		All	91	-0.00058	0.00092
	99% CI, One-Sided		91	-0.00005	0.00101
		None	91	-0.00000	0.00047
	99% CI, Two-Sided	Half	91	-0.00003	0.00065
		All	91	-0.00005	0.00101

Table 4.20. Summary statistics for RU_t: 6-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		91	0.00370	0.00124
	95% CI, Two-Sided	None	91	0.00076	0.00034
		Half	91	0.00198	0.00070
		All	91	0.00319	0.00127
	99% CI, One-Sided		91	0.00267	0.00131
	99% CI, Two-Sided	None	91	0.00076	0.00034
		Half	91	0.00164	0.00072
		All	91	0.00252	0.00133
ASI Predictions	95% CI, One-Sided		91	0.00070	0.00111
	95% CI, Two-Sided	None	91	-0.00059	0.00050
		Half	91	0.00024	0.00073
		All	91	0.00108	0.00117
	99% CI, One-Sided		91	0.00117	0.00117
	99% CI, Two-Sided	None	91	-0.00038	0.00049
		Half	91	0.00578	0.00073
		All	91	0.00153	0.00119

Table 4.21. Summary statistics for RH_t: 3-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		104	0	0
	95% CI, Two-Sided	None	104	-0.00161	0.00117
		Half	104	-0.00081	0.00039
		All	104	0	0
	99% CI, One-Sided		104	0	0
	99% CI, Two-Sided	None	104	-0.00199	0.00088
		Half	104	-0.00100	0.00044
		All	104	0	0
ASI Predictions	95% CI, One-Sided		104	-0.00356	0.00072
	95% CI, Two-Sided	None	104	-0.00453	0.00074
		Half	104	-0.00399	0.00071
		All	104	-0.00344	0.00072
	99% CI, One-Sided		104	-0.00336	0.00072
	99% CI, Two-Sided	None	104	-0.00465	0.00074
		Half	104	-0.00394	0.00070
		All	104	-0.00323	0.00071

Table 4.22. Summary statistics for RH_t: 3-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		104	0	0
	95% CI, Two-Sided	None	104	-0.00208	0.00087
		Half	104	-0.00104	0.00044
		All	104	0	0
	99% CI, One-Sided		104	0	0
	99% CI, Two-Sided	None	104	-0.00239	0.00090
		Half	104	-0.00120	0.00045
		All	104	0	0
ASI Predictions	95% CI, One-Sided		104	-0.00377	0.00072
	95% CI, Two-Sided	None	104	-0.00424	0.00076
		Half	104	-0.00401	0.00072
		All	104	-0.00377	0.00072
	99% CI, One-Sided		104	-0.00342	0.00071
	99% CI, Two-Sided	None	104	-0.00433	0.00076
		Half	104	-0.00379	0.00071
		All	104	-0.00325	0.00070

Table 4.23. Summary statistics for RH_t: 6-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		91	0.00114	0.00065
	95% CI, Two-Sided	None	91	-0.00212	0.00132
		Half	91	-0.00063	0.00081
		All	91	0.00086	0.00053
	99% CI, One-Sided		91	-0.00003	0.00043
	99% CI, Two-Sided	None	91	-0.00224	0.00132
		Half	91	-0.00124	0.00075
		All	91	-0.00025	0.00041
ASI Predictions	95% CI, One-Sided		91	-0.00358	0.00096
	95% CI, Two-Sided	None	91	-0.00300	0.00126
		Half	91	-0.00323	0.00105
		All	91	-0.00345	0.00096
	99% CI, One-Sided		91	-0.00293	0.00089
	99% CI, Two-Sided	None	91	-0.00288	0.00127
		Half	91	-0.00290	0.00100
		All	91	-0.00293	0.00089

Table 4.24. Summary statistics for RH_t: 6-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		91	0.00082	0.00047
	95% CI, Two-Sided	None	91	-0.00212	0.00132
		Half	91	-0.00090	0.00075
		All	91	0.00032	0.00041
	99% CI, One-Sided		91	-0.00020	0.00032
	99% CI, Two-Sided	None	91	-0.00212	0.00132
		Half	91	-0.00124	0.00070
		All	91	-0.00036	0.00028
ASI Predictions	95% CI, One-Sided		91	-0.00218	0.00079
	95% CI, Two-Sided	None	91	-0.00347	0.00123
		Half	91	-0.00264	0.00086
		All	91	-0.00180	0.00070
	99% CI, One-Sided		91	-0.00170	0.00070
	99% CI, Two-Sided	None	91	-0.00325	0.00125
		Half	91	-0.00230	0.00084
		All	91	-0.00134	0.00067

(Table 4.17). Therefore, a bank following either one of these decision rules is faced with MMC rates which average 12.5 or 13.7 basis points below the rates it would face if it did not hedge at all. For the 6-month hedge, the decision rules based on the ASI predictions yield insignificant values for RU_t, suggesting that a bank following one of these decision rules pays rate on MMCs which are not different, on the average, from the unhedged rates.

For RH_t, some of the decision rules based on the futures market predictions yield significant negative mean values for both the 3-month and 6-month hedges. These decision rules are based on the two-sided CIs where either none or half of the position is hedged if rates are expected to change. For the other decision rules based on futures preditions, RH_t has means and standard errors of zero for the 3-month hedge and insignificant means for the 6-month hedge. These decision rules are based on one-sided CIs and two-sided CIs where the entire position is hedged if rates are not expected to change.

All of the decision rules based on the ASI predictions yield significant negative values for RH_t for both the 3-month and the 6-month hedges. In all instances, the ASI decision rules show improvement over the futures market decision rules. For the 3-month hedge, the best results occur for the decision rules based on the two-sided CIs where the position is not hedged if rates are not expected to change. The mean values of RH_t are -0.00453 for the 95% case and -0.00465 for the 99% case (Table 4.21). Thus, a bank following either of these decision rules pays, on the average, 45.3 or 46.5 basis points less on MMCs than it would pay if it hedged all of the time. For the 6-month hedge, the best results occur for the decision rules based on the one-sided CIs or the two-sided CIs where the entire position is hedged when rates are not expected to change. The mean value of RH_t is -0.00358 for the 95% one-sided case and -0.00293 for the 99% one-sided case (Table 4.23). Thus, a bank following these decision rules for a 6-month hedge pays, on the average, 35.8 or 29.3 basis points less on MMCs than it would pay if it hedged all of the time.

Separating the data into the three groups of months to determine the boundaries of the decision rules does occasionally offer some improvement in the results for the model, but these improvements are not very consistent. For the futures market predictions, the separated data does produce lower mean values of RH_t for both the 3-month and 6-month hedges. However, the best results overall for RH_t occur with the ASI predictions and the pooled data. For the 3-month hedge, the 99% 2-sided CI decision rule where none of the position is hedged if rates are expected to change results in a RH_t mean value of -0.00465 for the pooled data and -0.00433 for the separated data (Tables 4.21 and 4.22). For the 6-month hedge, the 95% one-sided CI decision rules results in a RH_t mean of -0.00358 for the pooled data and -0.00218 for the separated data (Tables 4.23 and 4.24). For RU_t, the decision rules based on the separated data produce results which are either similar or inferior to those produced by the decision rules based on the pooled data. Thus, separating the data to determine the boundaries of the decision rules does not appear to produce any substantial benefits to the model.

For the decision rules based on the two-sided confidence intervals, the choice of how to act if interest rates are not expected to change has some impact on the results. For the most part, the two-sided CI decision rules result in means of RU_t and RH_t that are lower when the position is not hedged when rates are not expected to change than when the position is hedged under the same circumstances. This may be due to transaction costs, which amount to four basis points per hedge. These costs automatically make hedging more expensive than not hedging when rates do not change. Also, if interest rates are trending downward during the testing period, the unhedged position will tend to offer lower rates than the hedged position. Thus, at least for the time frame tested in this model, it seems that a strategy which discourages hedging is going to result in lower MMC rates than one which encourages hedging.

There are some cases where the two-sided CI decision rules result in means of RU_t and RH_t that are lower when the position is hedged if rates are not expected to change than when the position is not hedged under the same circumstances. For the 6-month hedge, all months pooled together, ASI predictions, both the 95% and 99% two-sided CI decision rules show the means of RU_t and RH_t decreasing as a larger portion of the position is hedged when rates are not expected to change (Tables 4.19 and 4.23). Thus, for the 6-month hedge, pooled data, ASI predictions, it seems that a strategy which encourages hedging produces better results than one which discourages hedging, at least for the time frame tested in this model.

Analysis of risk

In order to determine whether risk reduction is preserved by following a selective hedging strategy, the standard errors of UP_t, HP_t and RP_t (defined in Chapter III) are examined.

We begin by looking at UP_t, the unhedged position, and HP_t, the hedged position. The summary statistics are given in Table 4.25. For the 3-month hedge, the standard error of the hedged position is 0.00028, compared with 0.00100 for the unhedged position. Therefore, by cross-hedging its 3-month MMCs with T-bill futures, a bank can reduce its exposure to interest rate risk to less than one-third of its unhedged risk. For the 6-month hedge, the hedged position has a standard error of 0.00051, compared to 0.00136 for the unhedged position. Thus, the bank is able to reduce its exposure to interest rate risk on 6-month MMCs to a little more than a third of its unhedged risk.

It is expected that the risk for the decision model falls somewhere between the two extremes of risk associated with the hedged position and the unhedged position. The standard error of RP_t over the entire data set gives an indication of the risk the bank faces by following the decision rules. The results are given in Tables 4.26-4.29. For the 3-month hedges/ASI predictions, the standard errors of RP_t are around 0.0008, which is closer to the unhedged position than the hedged position. For the 6-month hedges/ASI predictions, RP_t has standard errors ranging from 0.00085 (which is closer to the hedged position than it is to the unhedged position) to 0.00131 (which is very close to the unhedged position). The results for the futures predictions are more erratic. For the 3-month

Table 4.25. Summary statistics for UP_t, HP_t

	Statistic	Number of Observations	Mean	Standard Error
3-month hedges	UP_t	104	-0.00038	0.00100
	HP_t	104	-0.00366	0.00028
6-month hedges	UP_t	91	-0.00383	0.00136
	HP_t	91	-0.00670	0.00051

Table 4.26. Summary statistics for RP_t: 3-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		104	-0.00366	0.00028
	95% CI, Two-Sided	None	104	-0.00205	0.00089
		Half	104	-0.00286	0.00053
		All	104	-0.00366	0.00028
	99% CI, One-Sided		104	-0.00366	0.00029
	99% CI, Two-Sided	None	104	-0.00167	0.00098
		Half	104	-0.00267	0.00057
		All	104	-0.00366	0.00028
ASI Predictions	95% CI, One-Sided		104	-0.00011	0.00083
	95% CI, Two-Sided	None	104	0.00087	0.00083
		Half	104	0.00032	0.00081
		All	104	-0.00022	0.00082
	99% CI, One-Sided		104	-0.00031	0.00082
	99% CI, Two-Sided	None	104	0.00099	0.00083
		Half	104	0.00028	0.00080
		All	104	-0.00043	0.00081

Table 4.27. Summary statistics for RP_t: 3-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		104	-0.00366	0.00028
	95% CI, Two-Sided	None	104	-0.00159	0.00093
		Half	104	-0.00262	0.00053
		All	104	-0.00366	0.00028
	99% CI, One-Sided		104	-0.00366	0.00028
	99% CI, Two-Sided	None	104	-0.00127	0.00096
		Half	104	-0.00247	0.00054
		All	104	-0.00366	0.00028
ASI Predictions	95% CI, One-Sided		104	0.00011	0.00081
	95% CI, Two-Sided	None	104	0.00058	0.00084
		Half	104	0.00034	0.00081
		All	104	0.00011	0.00081
	99% CI, One-Sided		104	-0.00025	0.00081
	99% CI, Two-Sided	None	104	0.00066	0.00084
		Half	104	0.00013	0.00080
		All	104	-0.00041	0.00080

Table 4.28. Summary statistics for RP_t: 6-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		91	-0.00785	0.00083
	95% CI, Two-Sided	None	91	-0.00458	0.00133
		Half	91	-0.00608	0.00091
		All	91	-0.00757	0.00077
	99% CI, One-Sided		91	-0.00668	0.00070
	99% CI, Two-Sided	None	91	-0.00446	0.00134
		Half	91	-0.00546	0.00086
		All	91	-0.00646	0.00068
ASI Predictions	95% CI, One-Sided		91	-0.00312	0.00109
	95% CI, Two-Sided	None	91	-0.00370	0.00131
		Half	91	-0.00348	0.00113
		All	91	-0.00326	0.00108
	99% CI, One-Sided		91	-0.00378	0.00103
	99% CI, Two-Sided	None	91	-0.00378	0.00103
		Half	91	-0.00380	0.00109
		All	91	-0.00383	0.00131

Table 4.29. Summary statistics for RP_t: 6-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
Futures Predictions	95% CI, One-Sided		91	-0.00753	0.00069
	95% CI, Two-Sided	None	91	-0.00459	0.00133
		Half	91	-0.00580	0.00084
		All	91	-0.00702	0.00066
	99% CI, One-Sided		91	-0.00650	0.00061
	99% CI, Two-Sided	None	91	-0.00459	0.00133
		Half	91	-0.00547	0.00080
		All	91	-0.00634	0.00059
ASI Predictions	95% CI, One-Sided		91	-0.00453	0.00096
	95% CI, Two-Sided	None	91	-0.00323	0.00127
		Half	91	-0.00407	0.00096
		All	91	-0.00490	0.00089
	99% CI, One-Sided		91	-0.00500	0.00089
	99% CI, Two-Sided	None	91	-0.00345	0.00127
		Half	91	-0.00441	0.00094
		All	91	-0.00536	0.00085

hedge, RP_t has standard errors ranging from 0.00028 for the decision rules which tend to encourage hedging to 0.00098 for those which discourage hedging. The 0.00028 value is identical to the hedged position, while the 0.00098 is only slightly better than the unhedged position. For the 6-month hedge, RP_t has standard errors ranging between 0.00059 for the decision rules which encourage hedging to 0.00134 for those which discourage hedging. As in the 3-month hedge, the former value is very close to the hedged position, while the latter is very close to the unhedged position.

Of course, as stated in Chapter III, the goal of the selective hedge is to allow the banks to reduce the risk of rates increasing while taking advantage of the situations when rates are decreasing. Therefore, it is acceptable to the bank (even preferable) to have a high standard error when rates are lower than the target. The banks would prefer to maintain a low standard error when rates are higher than the target. Dividing the observations into two groups, one where the actual rates are lower than the target rates ($RP_t>0$) and one where the actual rates are higher than the target rates ($RP_t<0$), gives an indication of the risk associated with each case (Tables 4.30-4.37).

For the cases when the actual realized rate is lower than the target rate ($RP_t>0$), high standard errors of RP_t are desired because they represent volatility (in the form of MMC rates dropping) which is favorable to the bank. For the 3-month hedge, all months pooled together, the standard errors of $RP_t>0$ range from 0.00020 to 0.00146 for the futures predictions and from 0.00121 to 0.00180 for the ASI prediction, depending

Table 4.30. Summary statistics for $RP_t > 0$, $RP_t < 0$: 3-month hedges; decision rules based on all months pooled together; futures predictions

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
$RP_t > 0$	95% CI, One-Sided		12	0.00070	0.00020
	95% CI, Two-Sided	None	30	0.00908	0.00146
		Half	25	0.00453	0.00085
		All	12	0.00070	0.00020
	99% CI, One-Sided		12	0.00070	0.00020
	99% CI, Two-Sided	None	36	0.00926	0.00133
		Half	29	0.00475	0.00079
		All	12	0.00070	0.00020
$RP_t < 0$	95% CI, One-Sided		92	-0.00423	0.00027
	95% CI, Two-Sided	None	74	-0.00656	0.00050
		Half	79	-0.00519	0.00035
		All	92	-0.00423	0.00027
	99% CI, One-Sided		92	-0.00423	0.00027
	99% CI, Two-Sided	None	68	-0.00746	0.00055
		Half	75	-0.00553	0.00036
		All	92	-0.00423	0.00027

Table 4.31. Summary statistics for $RP_t > 0$, $RP_t < 0$: 3-month hedges; decision rules based on all months pooled together; ASI predictions

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
$RP_t > 0$	95% CI, One-Sided		28	0.01118	0.00161
	95% CI, Two-Sided	None	40	0.00922	0.00124
		Half	35	0.00906	0.00146
		All	27	0.01124	0.00167
	99% CI, One-Sided		26	0.01141	0.00173
	99% CI, Two-Sided	None	41	0.00916	0.00121
		Half	36	0.00856	0.00145
		All	25	0.01150	0.00180
$RP_t < 0$	95% CI, One-Sided		76	-0.00427	0.00028
	95% CI, Two-Sided	None	64	-0.00435	0.00032
		Half	69	-0.00411	0.00031
		All	77	-0.00424	0.00028
	99% CI, One-Sided		78	-0.00422	0.00028
	99% CI, Two-Sided	None	63	-0.00433	0.00033
		Half	68	-0.00411	0.00032
		All	79	-0.00421	0.00028

Table 4.32. Summary statistics for $RP_t > 0$, $RP_t < 0$: 3-month hedge; decision rules based on months separated into three groups; futures predictions

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
$RP_t > 0$	95% CI, One-Sided		12	0.00070	0.00020
	95% CI, Two-Sided	None	37	0.00829	0.00130
		Half	26	0.00451	0.00087
		All	12	0.00070	0.00020
	99% CI, One-Sided		12	0.00070	0.00020
	99% CI, Two-Sided	None	39	0.00859	0.00124
		Half	27	0.00472	0.00085
		All	12	0.00070	0.00020
$RP_t < 0$	95% CI, One-Sided		92	-0.00423	0.00027
	95% CI, Two-Sided	None	67	-0.00704	0.00056
		Half	78	-0.00500	0.00035
		All	92	-0.00423	0.00027
	99% CI, One-Sided		92	-0.00423	0.00027
	99% CI, Two-Sided	None	65	-0.00719	0.00059
		Half	77	-0.00499	0.00036
		All	92	-0.00423	0.00027

Table 4.33. Summary statistics for $RP_t > 0$, $RP_t < 0$: 3-month hedge; decision rules based on months separated into three groups; ASI predictions

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
$RP_t > 0$	95% CI, One-Sided		31	0.01019	0.00151
	95% CI, Two-Sided	None	40	0.00894	0.00126
		Half	37	0.00884	0.00137
		All	31	0.01019	0.00151
	99% CI, One-Sided		28	0.01053	0.00165
	99% CI, Two-Sided	None	41	0.00885	0.00124
		Half	36	0.00848	0.00143
		All	26	0.01095	0.00174
$RP_t < 0$	95% CI, One-Sided		73	-0.00417	0.00029
	95% CI, Two-Sided	None	64	-0.00465	0.00033
		Half	67	-0.00435	0.00030
		All	73	-0.00417	0.00029
	99% CI, One-Sided		76	-0.00422	0.00028
	99% CI, Two-Sided	None	63	-0.00466	0.00036
		Half	68	-0.00430	0.00030
		All	78	-0.00420	0.00028

Table 4.34. Summary statistics for $RP_t > 0$, $RP_t < 0$: 6-month hedges; decision rules based on all months pooled together; futures predictions

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
$RP_t > 0$	95% CI, One-Sided		15	0.00386	0.00066
	95% CI, Two-Sided	None	25	0.01167	0.00206
		Half	23	0.00529	0.00083
		All	13	0.00375	0.00075
	99% CI, One-Sided		14	0.00362	0.00071
	99% CI, Two-Sided	None	26	0.01152	0.00198
		Half	24	0.00516	0.00080
		All	14	0.00362	0.00071
$RP_t < 0$	95% CI, One-Sided		76	-0.01016	0.00073
	95% CI, Two-Sided	None	66	-0.01074	0.00083
		Half	68	-0.00992	0.00074
		All	78	-0.00946	0.00068
	99% CI, One-Sided		77	-0.00855	0.00061
	99% CI, Two-Sided	None	65	-0.01085	0.00083
		Half	67	-0.00927	0.00067
		All	77	-0.00829	0.00059

Table 4.35. Summary statistics for $RP_t > 0$, $RP_t < 0$: 6-month hedges; decision rules based on all months pooled together; ASI predictions

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
$RP_t > 0$	95% CI, One-Sided		23	0.01032	0.00230
	95% CI, Two-Sided	None	27	0.01193	0.00191
		Half	26	0.00961	0.00207
		All	21	0.01088	0.00248
	99% CI, One-Sided		19	0.01009	0.00264
	99% CI, Two-Sided	None	27	0.01193	0.00191
		Half	26	0.00868	0.00199
		All	19	0.01009	0.00264
$RP_t < 0$	95% CI, One-Sided		68	-0.00767	0.00058
	95% CI, Two-Sided	None	64	-0.01030	0.00072
		Half	65	-0.00871	0.00060
		All	70	-0.00749	0.00058
	99% CI, One-Sided		72	-0.00744	0.00057
	99% CI, Two-Sided	None	64	-0.01047	0.00071
		Half	65	-0.00880	0.00060
		All	72	-0.00744	0.00057

Table 4.36. Summary statistics for $RP_t > 0$, $RP_t < 0$: 6-month hedge; decision rules based on months separated into three groups; futures predictions

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
$RP_t > 0$	95% CI, One-Sided		9	0.00371	0.00102
		None	25	0.01143	0.00209
	95% CI, Two-Sided	Half	20	0.00513	0.00099
		All	9	0.00371	0.00102
	99% CI, One-Sided		10	0.00352	0.00093
		None	25	0.01143	0.00209
	99% CI, Two-Sided	Half	20	0.00513	0.00099
		All	10	0.00352	0.00093
$RP_t < 0$	95% CI, One-Sided		82	-0.00876	0.00062
		None	66	-0.01066	0.00084
	95% CI, Two-Sided	Half	71	-0.00889	0.00069
		All	82	-0.00820	0.00059
	99% CI, One-Sided		81	-0.00774	0.00054
		None	66	-0.01066	0.00084
	99% CI, Two-Sided	Half	71	-0.00845	0.00063
		All	81	-0.00756	0.00051

Table 4.37. Summary statistics for $RP_t > 0$, $RP_t < 0$: 6-month hedge; decision rules based on months separated into three groups; ASI predictions

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	Number of Observations	Mean	Standard Error
$RP_t > 0$	95% CI, One-Sided		15	0.01001	0.00310
	95% CI, Two-Sided	None	27	0.01107	0.00200
		Half	24	0.00670	0.00190
		All	14	0.00884	0.00308
	99% CI, One-Sided		13	0.00947	0.00326
	99% CI, Two-Sided	None	27	0.01107	0.00200
		Half	22	0.00655	0.00202
		All	10	0.00995	0.00411
$RP_t < 0$	95% CI, One-Sided		76	-0.00739	0.00054
	95% CI, Two-Sided	None	64	-0.00927	0.00078
		Half	67	-0.00793	0.00064
		All	77	-0.00740	0.00054
	99% CI, One-Sided		78	-0.00741	0.00053
	99% CI, Two-Sided	None	64	-0.00958	0.00077
		Half	69	-0.00790	0.00063
		All	81	-0.00725	0.00052

on the decision rules. Clearly, the standard errors for the futures predictions are quite erratic, ranging from below the standard error of the hedged position (0.00028) to well above the standard error of the unhedged position (0.00100). On the other hand, the standard errors for the ASI predictions are consistently higher than the standard error for the unhedged position (Tables 4.30, 4.31). For the 6-month hedge, all months pooled together, the standard errors of $RP_t>0$ range from 0.00066 to 0.00206 for the futures predictions and from 0.00191 to 0.00264 for the ASI predictions (Tables 4.34, 4.35). The standard errors for the futures prediction are quite variable, ranging from slightly higher than 0.00051, the standard error for the hedged position, to much higher than 0.00136, the standard error of the unhedged position. The standard errors for the ASI predictions are also variable, but they are all higher than the standard error of the unhedged position. The fact that the ASI predictions consistently maintain higher standard errors for $RP_t>0$ indicates that they do a better job than the futures predictions of capturing favorable volatility for the bank.

For the cases when the actual, realized rate is higher than the target rate ($RP_t<0$), low standard errors of RP_t are desired because they represent unfavorable volatility (in the form of MMC rates rising). For the 3-month hedge, all months pooled together, the standard errors of $RP_t<0$ range from 0.00027 to 0.00055 for the futures predictions and from 0.00028 to 0.00033 for the ASI predictions. The standard error for the futures predictions vary from just below to almost double the standard error of the unhedged position (0.00028). The standard errors for ASI predictions are less variable than those for the futures predictions and only slightly higher than the standard error of the hedged position. For the 6-month hedge all months pooled together, $RP_t<0$ has standard errors ranging from 0.00059 to 0.00083 for the futures predictions and from 0.00057 to 0.00072 for the ASI predictions. These values are all consistently higher than 0.00051, the standard error of the hedged position. For the 6-month hedge, the ASI predictions produce slightly better results than the futures predictions, but the difference is not as dramatic as it is in the 3-month hedge. The standard errors of $RP_t<0$ in this case do not compare quite as favorably to the standard error of HP_t as they do in the 3-month hedge, but they still show improvement over the futures predictions. The fact that for the ASI predictions the standard errors of $RP_t<0$ are much closer to the standard error of HP_t than they are to the standard error of UP_t indicates that the bank is able to preserve its risk reduction when it follows these decision rules.

Further Analysis

Throughout the analysis, the means of RH_t are consistently lower than the means of RU_t, indicating that the selective hedging strategy shows more improvement over the "always hedge" strategy than it does over the "never hedge" strategy. This raises the question of whether the predictions are biased. A downward trend in interest rates would make the unhedged rates lower, on the average, than the hedged rates, causing the mean of RH_t to be lower than the mean of RU_t. If the predictions are not biased towards either rate increases or decreases, then opposite trends in the data should reverse the relative values of RU_t and RH_t. However, if the predictions are biased, the opposite trends would not create opposite conditions. For example, if rates trend downward from time t_0 to t_n and predictions are biased towards decreases in rates, then the results of the selective hedge will probably yield good results. RH_t will be strongly negative and RU_t less so. If rates are trending upwards from t_0 to t_n and predictions are still biased towards decreases, then the selective hedging strategy will yield poor results. RU_t might not decrease very much because the predictions will be discouraging hedging. RH_t might be strongly positive because the bank will not be hedging, even though the rates will be on the rise.

One way to check for any bias resulting from trends in the data might be to reverse the data and add it to the original data set, thus providing equal portions of data trending both ways. Unfortunately, there are two problems with using reversed data in this model. The first problem is that the model is based on a time series of interest rate forecasts which cannot be reversed and applied to previous time periods. For example, for the time series t_1, t_2, ..., t_n, the forecast for each period is the expected rate for the next period.

(4.9) $F_i = {}_iE(R_{i+1})$

where $i = 1, 2, \ldots, n$

${}_iE(R_{i+1})$ = the expectation at time i of the interest rate at time i+1.

If the data is reversed and added to the existing data set, the time series will consist of the periods t_1, t_2, ..., t_n, t_n, t_{n-1}, ..., t_1.

The forecasts of the second half of the time series should have the form

$$(4.10)\quad F_{n+i} = {}_{n+i}E(R_{n+i+1}) = {}_{n-i+1}E(R_{n-i}).$$

This is a forecast of an event which has already occurred; it is neither attainable nor logically sound.

The other problem with using backwards data for this model stems from the fact that implied forward rates are used as the target rates for the hedges. Implied forward rates are estimates of what the market says the spot rates will be at some point in the future. They are based on the differences between the rates of instruments along the yield curve. Because the shape of the yield curve does not change when the data is reversed, the implied forward rates, by definition, always refer to the future. It would be inconsistent to apply these forward-looking rates to backwards data.

While it is difficult to determine to what extent trends in the data lead to biased results, the fact that some of the ASI predictions yield significant negative values for both RH_t and RU_t is encouraging. This means that the bank was better off by following these decision rules than by following the "never hedge" strategy. So, even though MMC rates may have been decreasing more than they were increasing, the bank still benefits by hedging in some cases.

The success of the selective hedge strategy depends a great deal on the forecast data used in the model. The results in this study are consistently better with the ASI predictions than they are with the futures predictions. Both sets of forecast data used in this study consist of quarterly predictions of 90-day T-bill rates. Better results might be obtained if the forecasts were on a monthly, rather than quarterly, basis and if the security which is used in the forecasts more closely matched the securities being hedged in maturity, size and quality. Results are better for the 3-month selective hedge than they are for the 6-month selective hedge, due, in part, to the fact that 3-month forecasts tend to be better than 6-month forecasts. Using forecast data that is simply more accurate than the ASI's (if one exists) might improve the model, but the expense of developing better forecasts has to be measured against the reduced MMC rates that would result.

The success of the selective hedging strategy is also dependent upon the limits of the decision rules. No theoretical basis for choosing between the 95% or 99%, one-sided or two-sided CI decision rules is advanced by this model. Furthermore, it is not clear whether the hedging all, half or none of the portfolio is best if rates are not expected to change. Any differences in the empirical results for these various decision rules appear to be more dependent on trends in the data than on any theoretical reason for one to be preferred over the other. Still, the model does indicate that a selective hedging strategy can be effective at reducing an agricultural bank's MMC rates, given decent interest rate forecasts, without a substantial increase in risk over the "always hedge" strategy.

Overall view

The overall results of this study, including the means of RH_t and RU_t and the standard errors of $RP_t>0$ and $RP_t<0$, are presented in Tables 4.38 - 4.41.

The results are fairly consistent for the 3-month case. For the ASI predictions, all months pooled together, the lowest mean values for RU_t and RH_t are achieved with the two-sided CIs where none of the position is hedged if rates are not expected to change. The mean values for RU_t and RH_t are -0.00125 and -0.00453, respectively, for the 95% case and -0.00132 and -0.00465, respectively, for the 99% case (Table 4.38). Interestingly, the decision rules which produce the best results for RU_t and RH_t produce the least desirable results for $RP_t>0$ and $RP_t<0$, with $RP_t>0$ having its lowest standard error and $RP_t<0$ having its highest standard error for these cases. One would think that the decision rules which produce the better results would do a beter job of capturing favorable volatility and protecting against unfavorable volatility. Since the bank does not hedge as often under these decision rules, it has fewer transaction costs. The savings in transaction costs must outweigh the reduced rates which result from following a more conservative decision rule.

The results the 6-month case are slightly opposite to those for the 3-month case. For the ASI predictions, all months pooled together, the lowest mean values of RU_t and RH_t are produced by the decision rules based on one-sided CIs, with values of -0.00071 and -0.00358, respectively, for the 95% case and -0.00005 and -0.00293, respectively, for the 99% case (Table 4.40). It must be pointed out that the means of RU_t are not

Table 4.38. Overall results of the selective hedging strategy: 3-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	RU_t Mean	RH_t Mean	$RP_t>0$ Standard Error	$RP_t<0$ Standard Error
Futures Predictions	95% CI, One-Sided		0.00328	0	0.00020	0.00027
	95% CI, Two-Sided	None	0.00167	-0.00161	0.00146	0.00050
		Half	0.00247	-0.00081	0.00085	0.00035
		All	0.00328	0	0.00020	0.00027
	99% CI, One-Sided		0.00328	0	0.00020	0.00027
	99% CI, Two-Sided	None	0.00129	-0.00199	0.00133	0.00055
		Half	0.00228	-0.00100	0.00079	0.00036
		All	0.00328	0	0.00020	0.00027
ASI Predictions	95% CI, One-Sided		-0.00028	-0.00356	0.00161	0.00028
	95% CI, Two-Sided	None	-0.00125	-0.00453	0.00124	0.00032
		Half	-0.00071	-0.00399	0.00146	0.00031
		All	-0.00016	-0.00344	0.00167	0.00028
	99% CI, One-Sided		-0.00007	-0.00336	0.00173	0.00028
	99% CI, Two-Sided	None	-0.00137	-0.00465	0.00121	0.00033
		Half	-0.00066	-0.00394	0.00145	0.00032
		All	-0.00005	-0.00323	0.00180	0.00028

Table 4.39. Overall results of the selective hedging strategy: 3-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	RU_t Mean	RH_t Mean	$RP_t>0$ Standard Error	$RP_t<0$ Standard Error
Futures Predictions	95% CI, One-Sided		0.00328	0	0.00020	0.00027
	95% CI, Two-Sided	None	0.00120	-0.00208	0.00130	0.00056
		Half	0.00224	-0.00104	0.00087	0.00035
		All	0.00328	0	0.00020	0.00027
	99% CI, One-Sided		0.00328	0	0.00020	0.00027
	99% CI, Two-Sided	None	0.00089	-0.00239	0.00124	0.00059
		Half	0.00209	-0.00120	0.00085	0.00036
		All	0.00328	0	0.00020	0.00027
ASI Predictions	95% CI, One-Sided		-0.00049	-0.00377	0.00151	0.00029
	95% CI, Two-Sided	None	-0.00096	-0.00424	0.00126	0.00033
		Half	-0.00073	-0.00401	0.00137	0.00030
		All	-0.00049	-0.00377	0.00151	0.00029
	99% CI, One-Sided		-0.00014	-0.00342	0.00165	0.00028
	99% CI, Two-Sided	None	-0.00105	-0.00433	0.00124	0.00036
		Half	-0.00051	-0.00379	0.00143	0.00030
		All	0.00003	-0.00325	0.00174	0.00028

Table 4.40. Overall results of the selective hedging strategy: 6-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	RU_t Mean	RH_t Mean	$RP_t>0$ Standard Error	$RP_t<0$ Standard Error
Futures Predictions	95% CI, One-Sided		0.00402	0.00114	0.00066	0.00073
	95% CI, Two-Sided	None	0.00075	-0.00212	0.00206	0.00083
		Half	0.00225	-0.00063	0.00083	0.00074
		All	0.00374	0.00086	0.00075	0.00068
	99% CI, One-Sided		0.00285	-0.00003	0.00071	0.00061
	99% CI, Two-Sided	None	0.00063	-0.00224	0.00198	0.00083
		Half	0.00163	-0.00124	0.00080	0.00067
		All	0.00263	-0.00025	0.00071	0.00059
ASI Predictions	95% CI, One-Sided		-0.00071	-0.00358	0.00230	0.00058
	95% CI, Two-Sided	None	-0.00013	-0.00300	0.00191	0.00072
		Half	-0.00035	-0.00323	0.00207	0.00060
		All	-0.00058	-0.00345	0.00248	0.00058
	99% CI, One-Sided		-0.00005	-0.00293	0.00264	0.00057
	99% CI, Two-Sided	None	-0.00000	-0.00288	0.00191	0.00071
		Half	-0.00003	-0.00290	0.00199	0.00060
		All	-0.00005	-0.00293	0.00264	0.00057

Table 4.41. Overall results of the selective hedging strategy: 6-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	RU_t Mean	RH_t Mean	$RP_t>0$ Standard Error	$RP_t<0$ Standard Error
Futures Predictions	95% CI, One-Sided		0.00370	0.00082	0.00102	0.00062
		None	0.00076	-0.00212	0.00209	0.00084
	95% CI, Two-Sided	Half	0.00198	-0.00090	0.00099	0.00069
		All	0.00319	0.00032	0.00102	0.00059
	99% CI, One-Sided		0.00267	-0.00020	0.00093	0.00054
		None	0.00076	-0.00212	0.00209	0.00084
	99% CI, Two-Sided	Half	0.00164	-0.00124	0.00099	0.00063
		All	0.00252	-0.00036	0.00093	0.00051
ASI Predictions	95% CI, One-Sided		0.00070	-0.00218	0.00310	0.00054
		None	-0.00059	-0.00347	0.00200	0.00078
	95% CI, Two-Sided	Half	0.00024	-0.00264	0.00190	0.00064
		All	0.00108	-0.00180	0.00308	0.00054
	99% CI, One-Sided		0.00117	-0.00170	0.00326	0.00053
		None	-0.00038	-0.00325	0.00200	0.00077
	99% CI, Two-Sided	Half	0.00578	-0.00230	0.00202	0.00063
		All	0.00153	-0.00134	0.00411	0.00052

significantly different from zero, suggesting that the values of RH_t carry more weight than the values of RU_t for the 6-month case. Unlike the 3-month case, the decision rules which produce the best means for RH_t also produce the most desirable standard errors for $RP_t>0$ and $RP_t<0$. In this case, the benefits of a more conservative decision rule must outweigh the increased transaction costs that result from hedging more often.

What do the results that have been presented in the study mean, in dollar terms, for an agricultural bank? The dollar effects of the decision rules for $1 million offerings of MMCs are presented in Tables 4.42-4.45. For the 3-month case, the dollar figures are determined by multiplying the means of RU_t and RH_t by the dollar amount of MMCs to be issued ($1 million) and dividing by four (since the loans are 3-months in duration and the rates are quoted on a yearly basis). For the ASI predictions, all months pooled together, the selective hedging strategy results in liability interest payments which are between $12.50 and $312.50 lower than the "never hedge" strategy and between $807.50 and $1162.50 lower than the "always hedge" strategy for every $1 million in MMCs that are issued. For the 6-month case, the means of RU_t and RH_t are multiplied by the dollar amount of MMCs to be issued and divided by two (since the loans are 3-months in duration). For the ASI predictions, all months pooled together, the selective hedging strategy results in liability interest payments which are between $0 and $355 lower than the "never hedge" strategy and between $1615 and $2325 lower than the "always hedge" strategy for every $1 million issued in MMCs. In terms of interest rates, the selective hedging strategy shows a greater advantage over the

Table 4.42. Results of the selective hedging strategy, in dollar terms: 3-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	$1 Million in 3-Month MMCs: Mean $ Change over "Never Hedge" Strategy	$1 Million in 3-Month MMCs: Mean $ Change over "Always Hedge" Strategy
Futures Predictions	95% CI, One-Sided		820	0
	95% CI, Two-Sided	None	417.5	-402.5
		Half	617.5	-202.5
		All	820	0
	99% CI, One-Sided		820	0
	99% CI, Two-Sided	None	322.5	-497.5
		Half	570	-250
		All	820	0
ASI Predictions	95% CI, One-Sided		-70	-890
	95% CI, Two-Sided	None	-312.5	-1132.5
		Half	-177.5	-997.5
		All	-40	-860
	99% CI, One-Sided		-17.5	-840
	99% CI, Two-Sided	None	-342.5	-1162.5
		Half	-165	-985
		All	-12.5	-807.5

Table 4.43. Results of the selective hedging strategy, in dollar terms: 3-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	$1 Million in 3-Month MMCs: Mean $ Change over "Never Hedge" Strategy	Mean $ Change over "Always Hedge" Strategy
Futures Predictions	95% CI, One-Sided		820	0
	95% CI, Two-Sided	None	300	-520
		Half	560	-260
		All	820	0
	99% CI, One-Sided		820	0
	99% CI, Two-Sided	None	222.5	-597.5
		Half	522.5	-300
		All	820	0
ASI Predictions	95% CI, One-Sided		-122.5	-942.5
	95% CI, Two-Sided	None	-240	-1060
		Half	-182.5	-1002.5
		All	-122.5	-942.5
	99% CI, One-Sided		-35	-855
	99% CI, Two-Sided	None	-262.5	-1082.5
		Half	-127.5	-947.5
		All	-7.5	-812.5

Table 4.44. Results of the selective hedging strategy, in dollar terms: 6-month hedge; decision rules based on all months pooled together

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	$1 Million in 6-month MMCs: Mean $ Change over "Never Hedge" Strategy	Mean $ Change over "Always Hedge" Strategy
Futures Predictions	95% CI, One-Sided		2010	570
		None	375	-1060
	95% CI, Two-Sided	Half	1125	-315
		All	1870	430
	99% CI, One-Sided		1425	-15
		None	315	-1120
	99% CI, Two-Sided	Half	815	-620
		All	1315	-125
ASI Predictions	95% CI, One-Sided	.	-355	-1790
		None	-65	-1500
	95% CI, Two-Sided	Half	-175	-1615
		All	-290	-1725
	99% CI, One-Sided		-25	-1465
		None	-0	-1440
	99% CI, Two-Sided	Half	-15	-1450
		All	-25	-1465

Table 4.45. Results of the selective hedging strategy, in dollar terms: 6-month hedge; decision rules based on months separated into three groups

	Decision Rule	Portion of Position Hedged When Rates Not Expected to Change (2-Sided CIs Only)	$1 Million in 6-Month MMCs: Mean $ Change over "Never Hedge" Strategy	$1 Million in 6-Month MMCs: Mean $ Change over "Always Hedge" Strategy
Futures Predictions	95% CI, One-Sided		1850	410
	95% CI, Two-Sided	None	380	-1060
		Half	990	-450
		All	1595	160
	99% CI, One-Sided		1335	-100
	99% CI, Two-Sided	None	380	-1060
		Half	820	-620
		All	1260	-180
ASI Predictions	95% CI, One-Sided		350	-1090
	95% CI, Two-Sided	None	-295	-1735
		Half	120	-1320
		All	540	-900
	99% CI, One-Sided		585	-850
	99% CI, Two-Sided	None	-190	-1625
		Half	2890	-1150
		All	765	-670

"always hedge" strategy in the 3-month case than it does in the 6-month case. However, in dollar terms, the selective hedging strategy actually shows greater advantage over the "always hedge" in the 6-month case, due to the longer maturity of the securities involved.

It is difficult to put the risk reduction qualities of the selective hedging strategy into dollar terms. In this study, interest rate risk is measured by the standard error around the mean of the difference between the target rate and the actual rate. However, the levels of risk associated with the various decision rules of the selective hedging strategy can be compared with the risk for the unhedged and hedged positions. For the 3-month hedge, the risk of the actual MMC rate being higher than the target rate ($RP_t<0$) is roughly one-third of the unhedged risk and about even with the hedged risk. Similar results are also obtained for the 6-month selective hedging strategy for certain decision rules.

CHAPTER V. CONCLUSIONS

The results of this study indicate that there is an opportunity for agricultural banks to lower their MMC rates by using a selective hedging strategy. Of the two sets of forecast data used in this study, the ASI predictions yield consistently better results than the futures market, suggesting that the ASI does a better job of forecasting interest rate changes. The model works better for 3-month hedges than for 6-month hedges, possibly because it is more difficult to predict rates over longer periods.

In the analysis of the risk associated with the selective hedge, the ASI predictions prove superior to the futures predictions, particularly for the 3-month hedge.

Separating the data into the three groups to determine POWER produces results that are no better than leaving them separate. This may be due to the reduced number of observations that result from separating the data.

There is some concern over whether trends in the data severely bias the results of this study. The model consistently shows greater improvement over the "always hedge" case than over the "never hedge" case, suggesting that interest rates trend downward during the period covered by this study. Equal, but opposite, trends should result in the selective hedge showing an increase in improvement over the "never hedge" and a decrease in improvement over the "always hedge" case, unless the decision rules are biased towards indicating rate decreases. One way to check for this bias would be to reverse the data and add it to the original data set, thus providing equal portions of data trending up and down. Unfortunately, the use of forecast data and implied forward rates in this model prohibits the reversing of the data.

The choice of the decision rules to be followed does have some effect on the results of the selective hedge. But there is no evidence indicating an overall preference of one particular decision rule over another. The benefits appear to be a result of peculiarities in the data, more than anything else. The model does not offer any explanation to this.

The results of this model could be improved by better and more frequent forecast data. The added benefits of using such data would have to be weighed against the extra cost of obtaining it. These costs may be beyond the reach of the typical agricultural bank.

When the results are interpreted in actual dollar figures, the selective hedging strategy appears to work as well for the 6-month case as it does for the 3-month case. This is because the longer term of the 6-month MMC, relative to the 3-month MMC, necessarily increases the amount of interest the bank is required to pay. Therefore, a certain percent savings in liability rates is necessarily worth more for a 6-month MMC than for a 3-month MMC, in terms of the actual payments involved.

Risk reduction capabilities of the selective hedging strategy cannot be put into dollar terms very well, but they can be compared to the unhedged and hedged positions. For both the 3-month and 6-month cases, the selective hedging strategy shows great improvement over the unhedged position and compares well with the hedged position.

BIBLIOGRAPHY

Abbott, Susan. "Small Banks Can Hedge, Too." Commodities 11 (June 1982): 50-51.

Arthur Andersen and Company. Accounting for Interest Rate Futures: An Explanation of the Proposed FASB Statement. Chicago: Arthur Andersen and Company, 1983.

Chicago Board of Trade. A Guide to Financial Futures at the Chicago Board of Trade. Chicago: Chicago Board of Trade, 1982.

Chicago Mercantile Exchange. Inside T-Bill Futures. Chicago: Chicago Mercantile Exchange, 1982a.

Chicago Mercantile Exchange. The International Monetary Market. Chicago: Chicago Mercantile Exchange, 1982b.

Cicchetti, Paul; Dale, Charles; and Vignola, Anthony. "Usefulness of Treasury Bill Futures as Hedging Instruments." The Journal of Futures Markets 1 (Summer 1981): 379-387.

Cole, Roger T. "Financial Performance of Small Banks, 1977-80." Federal Reserve Bulletin 67 (June 1981): 480-485.

Danker, Deborah J. and McLaughlin, Mary M. "Profitability of Insured Commercial Banks in 1983." Federal Reserve Bulletin 70 (November 1984): 802-811.

Dew, James Kurt. "Comment on 'Usefulness of Treasury Bill Futures as Hedging Instruments.'" The Journal of Futures Markets 1 (Summer 1981): 389-391.

Drabenstott, Mark and McDonley, Anne O'Mara. "The Impact of Financial Futures on Agricultural Banks." Economic Review, Federal Reserve Bank of Kansas City 67 (May 1982a): 19-30.

Drabenstott, Mark and McDonley, Anne O'Mara. "The Effect of Financial Futures on Small Bank Performance." Economic Review, Federal Reserve Bank of Kansas City 67 (November 1982b): 15-31.

Drabenstott, Mark and McDonley, Anne O'Mara. "Futures Markets: A Primer for Financial Institutions." Economic Review, Federal Reserve Bank of Kansas City 69 (November 1984): 17-33.

Ederington, Louis H. "The Hedging Performance of the New Futures Markets." The Journal of Finance 34 (March 1979): 157-170.

Edwards, Franklin R. "The Regulation of Futures and Forward Trading by Depository Institutions: A Legal and Economic Analysis." The Journal of Futures Markets 1 (Spring 1981): 201-218.

Franckle, Charles T. "The Hedging Performance of the New Futures Markets: Comment." The Journal of Finance 35 (December 1980): 1273-1279.

Franckle, Charles T. and Senchack, Andrew J., Jr. "Economic Considerations in the Use of Interest Rate Futures." The Journal of Futures Markets 2 (Winter 1982): 107-116.

Furlong, Frederick T. "New Deposit Instruments." Federal Reserve Bulletin 69 (May 1983): 319-326.

Garcia, Gillian and McMahon, Annie. "Regulatory Innovation: The New Bank Accounts." Economic Perspectives, Federal Reserve Bank of Chicago 8 (March/April 1984): 12-23.

Hayenga, Marvin L. and DiPietre, Dennis D. "Cross-Hedging Wholesale Pork Products Using Live Hog Futures." American Journal of Agricultural Economics 64 (November 1982): 747-751.

Johnson, Leland. "The Theory of Hedging and Speculation in Commodity Futures." Review of Economic Studies 27 (June 1960): 139-151.

Kolb, Robert W.; Timme, Stephen G.; and Gay, Gerald D. "Macro Versus Micro Futures Hedges at Commercial Banks." The Journal of Futures Markets 4 (Winter 1984): 47-54.

Lins, David A. "Interest Rate Risk Management." In Financial Futures and Options: Their Potential Use in Agriculture. North Central Regional Project N-161. Urbana, Illinois: Department of Agricultural Economics, University of Illinois at Urbana Champaign, 1984.

Loosigian, Alan. Interest Rate Futures. Homewood, Illinois: Dow-Jones-Irwin, 1960.

Opper, Barbara Negri. "Profitability of Insured Commercial Banks." Federal Reserve Bulletin 68 (August 1982): 453-465.

Overdahl, James Anthony. "The CD Futures Market: Hedging and Price Discovery Performance." Ph.D. dissertation. Iowa State University, 1984.

Powers, Mark and Vogel, David. Inside the Financial Futures Markets, Second edition. New York: John Wiley and Sons, 1984.

Senchack, Andrew J., Jr. and Easterwood, John C. "Cross-Hedging CDs with Treasury Bill Futures." The Journal of Futures Markets 3 (Autumn 1983): 429-438.

Stein, J. L. "The Simultaneous Determination of Spot and Futures Prices." American Economic Review 51 (December 1961): 1012-1025.

Wardrup, Bruce N. and Buck, James F. "The Efficacy of Hedging With Financial Futures: A Historical Perspective." The Journal of Futures Markets 2 (Spring 1982): 243-252.

ACKNOWLEDGEMENTS

I am indebted to everyone who offered their advice and encouragement throughout the course of this study. I want to thank the members of my thesis committee - Roger Dahlgran, Ron Deiter, Keith Howe - for their help. Marvin Hayenga offered valuable suggestions for the development of the research topic. Tim Lord of Manufacturers Hanover Futures, Inc., provided some of the data, along with Kim Norris of the Federal Reserve Bank of Kansas City. Many thanks to Beth Tesdahl, who spent long hours at the word processor, typing various drafts of this thesis. I owe a debt of gratitude to my major professor, Mike Boehlje, for his guidance throughout my graduate education at Iowa State. I especially want to thank my father for his patience and encouragement throughout.