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The Hedging Performance of the New Futures Markets

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ORGANIZED FUTURES MARKETS in financial securities were first established in the U.S. on October 20, 1975 when the Chicago Board of Trade opened a futures market in Government National Mortgage Association 8% Pass-Through Certificates. This was followed in January, 1976 by a 90 day Treasury Bill futures market on the International Monetary Market of the Chicago Mercantile Exchange. In terms of trading volume both have been clear commercial successes and this has led to the establishment, in 1977, of futures markets in Long Term Government Bonds and 90-day Commercial Paper and, in 1978, of a market in One-Year Treasury notes and new GNMA markets.

The classic economic rationale for futures markets is, of course, that they facilitate hedging—that they allow those who deal in a commodity to transfer the risk of price changes in that commodity to speculators more willing to bear such risks. The primary purpose of the present paper is to evaluate the GNMA and T-Bill futures markets as instruments for such hedging. Obviously it is possible to hedge by entering into forward contracts outside a futures market, but, as Telser and Higinbotham [19] point out, an organized futures market facilitates such transactions by providing a standardized contract and by substituting the trustworthiness of the exchange for that of the individual trader.

In the futures market, price change risk can be eliminated entirely by making or taking delivery on futures sold or bought, but few hedges are concluded in this manner.[1] The major problem with making or taking delivery is that there are only four delivery periods per year for financial security futures so it is often

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[1] It should perhaps be noted that in the GNMA market there would, however, be some uncertainty regarding the amount one would need to hold to make delivery. The futures contract is for $100,000 of GNMA 8% Pass-Through Certificates. Since prepayment on these certificates might occur prior to delivery, there is some uncertainty regarding the quantity one would need to hold at present in order to deliver $100,000 of certificates. This is mitigated by the fact that one can deliver certificates of between $97,500 and $102,500 face value with the deficiency or excess to be settled in cash but some uncertainty remains. In addition, the person who accepts delivery of GNMA futures faces uncertainty regarding the type and relative market value of the certificates to be received. While trading is in 8% certificates, certificates of any mortgage rate can be delivered as long as the quantity delivered is equivalent to $100,000 of 8% certificates assuming a thirty year certificate with total prepayment at the end of twelve years. Since the market doesn't always accept such arbitrary prepayment assumptions, it may be cheaper to deliver 6½% or 9% or some other certificates. Indeed, it has generally been cheaper to deliver 9% certificates [6]. Consequently, those accepting delivery may not receive $100,000 of 8% certificates or their market equivalent. This also means that at delivery the futures price for GNMA's will generally remain somewhat below the cash price.

It should also be noted that over the observed period, January 1976 through July 1977, futures prices were below cash prices except for a few occasions within a few weeks of delivery. Purchasers of impossible to hedge in this manner over the desired time period. Moreover, the desired time period may change or may be uncertain. The most common hedge, therefore, is one in which the seller (buyer) of the futures contract cancels his delivery commitment by buying (selling) a contract of the same future prior to delivery. It is this type of hedge, in which futures positions are liquidated by offsetting trades, which has received the most attention in the hedging literature and is examined in this paper.

In order to illustrate such a hedge and the potential of the new markets for risk avoidance, let us suppose that on September 16, 1977 a mortgage lending institution committed itself to a future loan at a set interest rate. Suppose, further, it was the lender's intention to finance this loan by issuing or selling $100,000 of 30 year GNMA Pass-Through Certificates with an 8% coupon rate which were selling at that time (September 16, 1977) at $99,531 or an effective yield of 8.02%.[2] Fearing that interest rates would rise and GNMA prices would fall by the time it actually sold its certificates, the mortgagor decided to hedge against this risk by selling December 1977 GNMA futures which were trading at $98,219 or an effective yield of 8.20% on September 16.[3] This transaction is summarized in the top half of Table 1.

In this particular case, our firm's fears of an interest rate rise were realized and the hedge was successful. By October 14, 1977, when the firm closed its loan and sold the GNMA certificates, cash market yields had risen 17 basis points to 8.19%. However, futures market yields had also risen 15 basis points to 8.30% so, as shown in Table 1, the futures market gain largely offset the cash market loss. This is a short hedge. If an individual or firm plans to purchase GNMA's, T-Bills, or some other security in the future, it could attempt to protect against the contingency of a decline in interest rates by buying GNMA or T-Bill futures, i.e., entering a long hedge. In this particular example, the hedge was successful because cash and futures prices both fell, but this may not always be the case.

There is not perfect agreement in the futures market literature as to what hedging is or why it is undertaken. The paper begins in Part I, therefore, with a survey of three major theories of hedging: the traditional theory, the theories of Holbrook Working, and the portfolio theory. The portfolio theory, which the author finds superior to the other two, suggests a method for measuring the hedging effectiveness of a futures market and this measure is used in Part II to evaluate the GNMA and T-Bill futures markets. These financial security futures are compared with each other and with two more established and heavily traded

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GNMA or T-Bill futures could therefore lock-in a lower price as well as a certain price but sellers of futures would have to be willing to lock-in a loss. On GNMA's, for example, the futures price averaged 1.9 below the cash price two months before delivery over the observed period and ranged from 1.1% below the cash price to 2.5% below.

[2] GNMA yields are calculated on the assumption of a prepayment after 12 years. The published market yields also take into account, as the face yields do not, that there is an interest free delay of 15 days in payments of principal and interest.

[3] Note that if the firm were to wait until December and make delivery, it would lock in exactly this price and yield but if it closes the hedge prior to delivery the price and yield are still somewhat uncertain.

At the present time there is no good data on what sort of firms are hedging in the market so this example is hypothetical. In addition, there are regulatory constraints on the participation of banks and S & L's (See Ederington and Plumly, 1976).

Table 1

A Possible Short Hedge Based on Actual Prices

Cash Market	Futures Market
September 16, 1977	
Makes mortgage commitment and makes plan to sell \$100,000 face value of GNMA 8% Certificates	Sells one December futures contract at \$98,219
Current price \$99,531	
October 14, 1977	
Sells GNMA 8% certificates (\$100,000 face value)	Buys one December futures contract at \$97,156
Current price \$98,281	

Results:	Loss from delay on cash market	\$1250
	Gain on futures market	1063
	Net Loss	\$ 187

futures markets: corn and wheat. The portfolio theory also provides a method for measuring the costs of hedging and these costs are examined for the two financial security futures. The article closes with a summary of the conclusions and some observations on possible future research in futures in Part III.

I. Theories of Hedging

A. *Traditional Hedging Theory*

While traditional hedging theory predates the work of Working and the application of portfolio theory to hedging, it continues to be important. Indeed, it is the traditional theory which underlies almost all the early "How To" articles on hedging which accompanied the establishment of the GNMA and T-Bill futures markets.[4]

Traditional hedging theory emphasizes the risk avoidance potential of futures markets. Hedgers are envisioned as taking futures market positions equal in magnitude but of opposite sign to their position in the cash market as in the example in Table 1. For instance, holders of an inventory of X units would protect themselves against the loss from a decline in the cash price by selling X futures of the same commodity or security. When the inventory is sold, futures contracts would be purchased canceling both positions.

If the cash or spot prices at times t_1 and t_2 are P_s^1 and P_s^2 respectively, the gain or loss on an unhedged position, U, of X units is $X[P_s^2 - P_s^1]$, but the gain or loss on a hedged position, H, is $X\{[P_s^2 - P_s^1] - [P_f^2 - P_f^1]\}$ where the f subscript denotes the futures price. Traditional theory argues that spot and futures prices generally move together so that the absolute value of H is less than U or that $\mathrm{Var}(H) < \mathrm{Var}(U)$. This question is often discussed in terms of the change in the cash price versus the change in the "Basis," where the basis is defined as the difference between the futures and spot prices so that the change in the basis is

[4] Examples are the Chicago Board of Trade's "Hedging in GNMA Interest Rate Futures" (1975) and articles by Smith [6], Jacobs and Kozuch [10], Sandor [5], Stevens [8], and Duncan [5].

$\{(P_f^2 - P_s^2) - (P_f^1 - P_s^1)\}$ or $-\{(P_s^2 - P_s^1) - (P_f^2 - P_f^1)\}$. A hedge is viewed as perfect if the change in the basis is zero. It is commonly argued that the basis and changes in the basis are small because of the possibility of making or taking delivery, hence $\mathrm{Var}(H) < \mathrm{Var}(U)$. The question of smallness is, of course, relative. While it is true that delivery possibilities limit changes in the basis, a range for variation obviously remains.

Certainly, the familiar theory of adaptive expectations implies that if futures prices reflect market expectations they should not normally match changes in cash prices. According to the theory of adaptive expectations

$$E_n^2 - E_n^1 = a[P_s^2 - E_2^1] + u$$

where E_n^2 and E_n^1 represent the cash prices expected to prevail in period n as of periods 2 and 1 respectively and E_2^1 represents the price which had in period 1, been expected to prevail in period 2. If one assumes that $P_f^2 = E_n^2$ and $P_f^1 = E_n^1$, one obtains

$$P_f^2 - P_f^1 = a[P_s^2 - P_s^1] - a[E_2^1 - P_s^1]$$

If, therefore, no change in spot prices is expected between periods 1 and 2 ($E_2^1 = P_s^1$) and a $\neq 1$, this theory implies that any change in the spot price will be accompanied by a proportional but unequal movement of the futures price. If, on the other hand, cash prices change in exactly the manner which had been expected ($P_s^2 = E_2^1$), then certainly there will be no change in futures prices.

While it is clear that the basis changes so that most traditional hedges are not perfect, Working [20] complained that many writers of the time were conveniently ignoring this fact:

> *A major source of mistaken notions of hedging is the conventional practice of illustrating hedging with a hypothetical example in which the price of the future bought or sold as a hedge is supposed to rise or fall by the same amount that the spot price rises or falls.* [20, pp. 320–321.]

In perusing articles and pamphlets on hedging in GNMA's and T-Bills, I have been surprised to note that many continue to follow the same practice almost 25 years later. This includes not only publications of the exchanges and brokerage houses and articles in trade publications, such as *Savings and Loan News* [16] and *The Mortgage Banker* [10], but also articles in the *Review of the Federal Reserve Bank of St. Louis* [18] and the *Federal Home Loan Bank Board Journal* [15]. In these articles, any caveat that cash and futures price changes may not be equal is relegated to a footnote or a discussion of cross-hedging.

B. *Working's Hypothesis*

Working [20 and 21] challenged the view of hedgers as pure risk minimizers and emphasized expected prfit maximization. In his view hedgers functioned much like speculators, but, since they held positions in the cash market as well, they were concerned with relative not absolute price changes. Instead of expecting cash and futures prices to move together, he argued that "most hedging is done in expectation of a change in spot-futures price relations [20]." Holders of a long position in the cash market would, according to Working, hedge if the basis was expected to fall and would not hedge if the basis was expected to rise.

C. *Portfolio and Hedging Theory*

By viewing hedging as a simple application of basic portfolio theory Johnson [11] and Stein [17] were able to integrate the risk avoidance of traditional theory with Working's expected profits maximization. Johnson and Stein argued that one buys or sells futures for the same risk-return reasons that one buys any other security. While traditional theory argued that hedgers should always be completely hedged and Working's hypothesis indicated (though he realized such was not always the case) that hedgers would be completely hedged or unhedged, the application of portfolio theory allowed Johnson and Stein to explain why hedgers would hold both hedged and unhedged commodity stocks.

While the portfolio model of hedging may contain nothing which is new to those in the finance field, it is less familiar to analysts of commodity futures markets and has experienced a somewhat slower acceptance in this field. Since we will use this model to evaluate the GNMA and T-Bill futures as hedging instruments in the next section, let us briefly summarize its important characteristics.

One difference between this and the more familiar portfolio model is that cash and futures market holdings are not viewed as substitutes. Instead, spot market holdings, X_s, are viewed as fixed and the decision is how much of this stock to hedge. Following Johnson and Stein, let us restrict our attention to the case in which the potential hedger holds only one spot market commodity or security. Since spot market holdings are exogenous, any interest payments may also be viewed as predetermined and therefore irrelevant to the hedging decision. Letting U represent once again the return on an unhedged position,

$$E(U) = X_s E[P_s^2 - P_s^1] \tag{1}$$

$$\mathrm{Var}(U) = X_s^2 \sigma_s^2 \tag{2}$$

Let R represent the return on a portfolio which includes both spot market holdings, X_s, and futures market holding[5], X_f.

$$E(R) = X_s E[P_s^2 - P_s^1] + X_f E[P_f^2 - P_f^1] - K(X_f) \tag{3}$$

$$\mathrm{Var}(R) = X_s^2 \sigma_s^2 + X_f^2 \sigma_f^2 + 2 X_s X_f \sigma_{sf} \tag{4}$$

where

X_s and X_f represent spot and futures market holdings.

$K(X_f)$ are brokerage and other costs of engaging in futures transactions including the cost of providing margin.

σ_s^2, σ_f^2, σ_{sf} represent the subjective variances and the covariance of the possible price changes from time 1 to time 2.

Note that the portfolio, whose returns are represented by R, may be a portfolio which is either completely are partially hedged. There is no presumption, as in traditional theory, that $X_f = -X_s$ (in which case $R = H$). Indeed cash and futures market holdings may even have the same sign.

Let $b = -X_f/X_s$ represent the proportion of the spot position which is hedged. Since in a hedge X_s and X_f have opposite signs, b is usually positive.

$$\mathrm{Var}(R) = X_s^2\{\sigma_s^2 + b^2\sigma_f^2 - 2b\sigma_{sf}\} \quad \text{and} \tag{5}$$

$$\begin{aligned} E(R) &= X_s\{E(P_s^2 - P_s^1) - bE(P_f^2 - P_f^1)\} - K(X_s, b) \\ &= X_s\{(1-b)E(P_s^2 - P_s^1) + bE(P_s^2 - P_s^1) - bE(P_f^2 - P_f^1)\} \\ &\quad - K(X_s, b) \end{aligned} \tag{6}$$

or, letting $E(\Delta b) = E\{P_f^2 - P_s^2 - (P_f^1 - P_s^1)\}$ represent the expected change in the basis,

$$E(R) = X_s[(1-b)\,E(S) - b\,E(\Delta B)] - K(X_s, b) \tag{7}$$

where $E(S) = E(P_s^2 - P_s^1)$ is the expected price change on one unit of the spot commodity.

If the expected change in the basis is zero, then clearly the expected gain or loss is reduced as $b \rightarrow 1$. It is also obvious that expected changes in the basis may add to or subtract from the gain or loss which would have been expected on an unhedged portfolio $\{E(U) = X_s \mathrm{E}(S)\}$.

Holding X_s constant, let us consider the effect of a change in b, the proportion hedged, on the expected return and variance of the portfolio R.

$$\frac{\partial\,\mathrm{Var}(R)}{\partial b} = X_s^2\{2b\sigma_f^2 - 2\sigma_{sf}\} \tag{8}$$

so the risk minimizing b, b^*, is

$$b^* = \frac{\sigma_{sf}}{\sigma_f^2} \tag{9}$$

$$\frac{\partial E(R)}{\partial b} = -X_s[E(\Delta B) + E(S)] - \frac{\partial K(X_s, b)}{\partial b} \tag{10}$$

Since $E(\Delta B)$ and $E(S)$ may be either positive or negative, the opportunity locus of the possible combinations of $E(R)$ and *Var(R),* which are shown in figure 1, may lie in either the first or second quadrant or both. Moreover, as b increases one moves either clockwise or counterclockwise around the locus depending on the sign of equation 10.

In this model there is no riskless asset. Treasury bills, which are usual candidate for a riskless asset, are themselves being hedged. One may wish to liquidate a position in bills prior to maturity in which case there is a price risk however small. Consequently, the optimal b, $\hat{b}$, will be that associated with the point on the indifference curve which is just tangent to the highest indifference curve, II′. Not only need $\hat{b}$ not equal one as traditional hedging theory presumed, but $\hat{b}$ may be greater than one, in which case one takes a greater position in the futures than in the cash market, or $\hat{b}$ may be less than zero, in which case one takes the same position (either short or long) in both the spot and futures markets.[5]

[5] Since one would normally assume that $\sigma_{sf} > 0$, $b^* > 0$ but since b may be either increasing or decreasing as one moves counterclockwise around the opportunity locus, the portion of the locus above b^* may represent either $b < b^*$ or $b < b^*$.

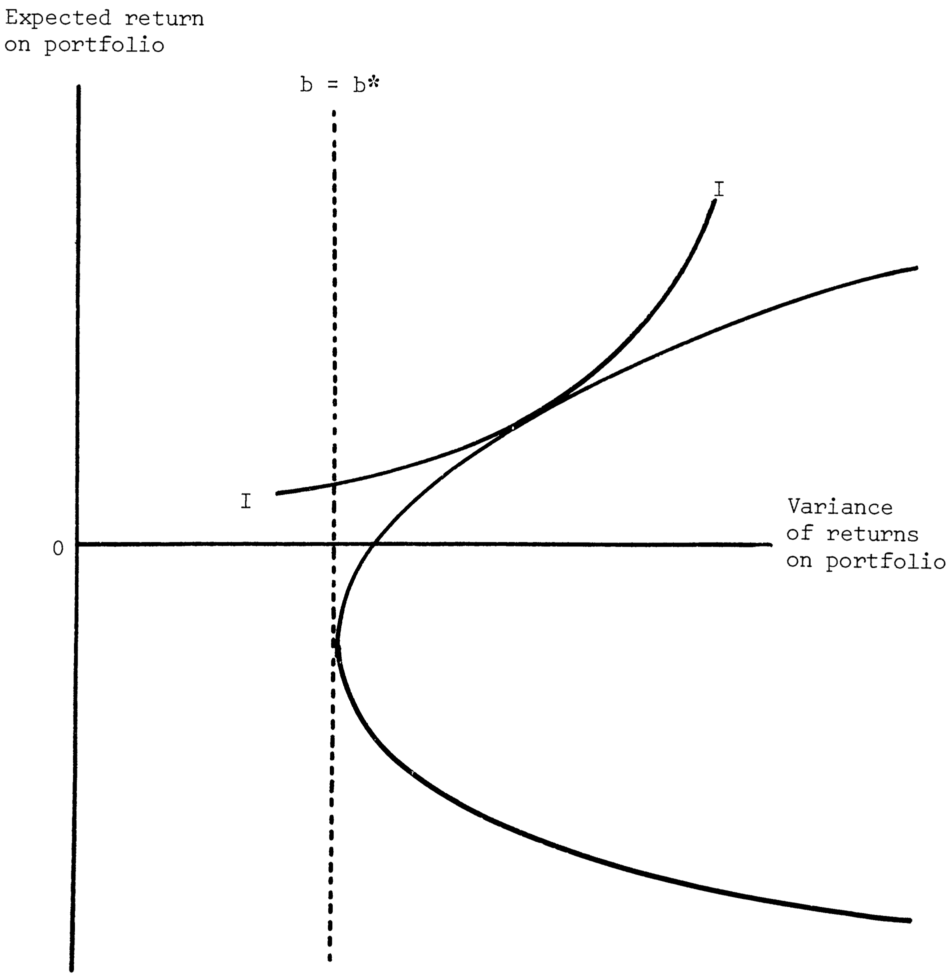

Figure 1

II. Evaluating the GNMA and T-Bill Futures Markets

The purpose of this section is to estimate the effectiveness of the new futures markets in reducing the risk associated with a cash position in GNMA's or T-Bills based on the market experience to date and to estimate the costs of hedging (the impact on expected returns).

While traditional theory indicates that the risk reduction to be achieved by hedging can be measured by comparing the variance of the change in the basis to the variance of the change in the cash price, this presumes that $b = 1$ which as shown above may not be the case. Fortunately, portfolio theory also provides a measure of hedging effectiveness. While the risk reduction achieved by any one hedger depends on the chosen b, the futures markets' potential for risk reduction can be measured by comparing the risk on an unhedged portfolio with the minimum risk that can be obtained on a portfolio containing both spot and forward securities. This minimum risk is represented by the left most point of the opportunity locus in figure 1, and corresponds to the variance of the return on a portfolio where b equals the b^* defined in equation 9. The measure of hedging effectiveness used in this paper is, therefore, the percent reduction in the variance or

$$e = 1 - \frac{\mathrm{Var}(R^*)}{\mathrm{Var}(U)}$$

where varR^* denotes the minimum variance on a portfolio containing security futures.

Substituting equation 9 into equation 5 yields

$$\mathrm{Var}(R^*) = X_s^2\left\{\sigma_s^2 + \frac{\sigma_{sf}^2}{\sigma_f^2} - 2\frac{\sigma_{sf}^2}{\sigma_f^2}\right\} = X_s^2\left(\sigma_s^2 - \frac{\sigma_{sf}^2}{\sigma^2 f}\right)$$

Consequently

$$e = \frac{\sigma_{sf}^2}{\sigma_s^2\sigma_f^2} = \rho^2$$

where ρ^2 is the population coefficient of determination between the change in the cash price and the change in the future's price.

In order to judge the market's effectiveness at reducing risk, we estimated e using the sample coefficient of determination, r^2, for hedges of two arbitrary lengths (two and four weeks) and using the sample variances and sample covariance of the two and four week price changes over the observed period to estimate b^* as well as σ_s^2, σ_f^2 and σ_{sf}. As noted above, the GNMA and T-Bill markets were established in October 1975 and January 1976 respectively. Since it seemed prudent to allow the markets to gain some depth before analyzing them, weekly data collection for the GNMA market began in January 1976 and for the T-Bill market in March 1976. Both data sets were continued through December 1977. For comparison purposes we also collected data (January 1976—December 1977) and calculated e for two established and heavily traded futures: corn and wheat.[6]

For T-Bill cash prices, 90-day T-Bill prices were consistently used because they were readily available. This ignores the fact that over the hedge period the term to maturity of any T-Bills held will decline. Actual hedgers would need to adjust their b according to the term of the T-Bills held and the length of the hedge [5].

Since a hedger can buy futures with near or distant delivery dates, hedges in futures with a delivery date in 3 months or less (the nearby contract), in 3 to 6 months, in 6 to 9 months, and in 9 to 12 months were evaluated separately.[7] It could be argued that one's expectations of the near future will be affected more by unexpected changes in the cash price than one's expectation of the more distant futures, and this is supported by some work on adaptive expectations using forward rates from the term structure [12]. Consequently, we hypothesize that e will decline as one considers more distant contracts.

[6] The futures prices were weekly closing prices as reported in the *Wall Street Journal*. For the spot price of wheat, we used the price of #2 Kansas City hard and for corn we used the price of #2 Chicago yellow as reported in the *Journal*.

[7] Two or four week periods in which the nearby contract expired were dropped from the sample. During the harvest season, futures contracts are available for every other month for corn and wheat, so the time periods for these differ somewhat from those for GNMA's and T-Bills.

Table 2

Two Week Hedges

The Futures Contract	Estimated e	Estimated b*
8% GNMA's (46 observations)		
The Nearby Contract	.664	.801*
3 to 6 Month Contract	.675	.832
6 to 9 Month Contract	.677	.854
9 to 12 Month Contract	.661	.852
90 Day Treasury Bills (41 observations)		
The Nearby Contract	.272	.307*
3 to 6 Month Contract	.256	.237*
6 to 9 Month Contract	.178	.143*
9 to 12 Month Contract	.140	.116
Wheat (45 observations)		
The Nearby Contract	.898	.864*
2 to 6 Month Contract	.889	.815*
4 to 8 Month Contract	.868	.784*
6 to 10 Month Contract	.841	.778*
Corn (45 observations)		
The Nearby Contract	.649	.915
2 to 6 Month Contract	.605	.905
4 to 8 Month Contract	.541	.868
6 to 10 Month Contract	.450	.764

* Significantly different from 1 at .05 level.

In addition, it is hypothesized that e will be greater for four week than for two week hedges because absolute changes in cash prices should generally be greater and futures prices would have more time to respond (if there is a lag) over the longer period.

The results for two week hedges are shown in Table 2 and the results for four week hedges are shown in Table 3. The most striking result is the marked superiority of the GNMA market to the T-Bill market particularly for the shorter hedges. While it appears less effective than the wheat market, the GNMA market compares quite favorably with the corn market as a hedging instrument. With the puzzling exception of hedges in the nearby contract for a four week period, the T-Bill market appears rather ineffective in reducing exposure to price change risk particularly over the shorter period. Indeed, if one followed the prescription of traditional theory and set $b = 1$, the hedged T-Bill portfolio would have been more risky than the unhedged portfolio in all cases except for four week hedges in the nearby contract. The author feels that this may be due to the fact that the T-Bill rate is closely related to the federal funds rate which, given current Federal Reserve operating procedures, is basically controlled by the Fed over short periods. If short-run changes in T-Bill rates are viewed as induced by monetary authorities, market participants may see no need to adjust their expectations of future rates.

While the author is unaware of any way to statistically test this hypothesis, the

Table 3

Four Week Hedges

The Futures Contract	Estimated e	Estimated b*
8% GNMA's (23 observations)		
The Nearby Contract	.785	.848
3 to 6 Month Contract	.817	.993
6 to 9 Month Contract	.799	1.019
9 to 12 Month Contract	.780	1.035
90 Day Treasury Bills (21 observations)		
The Nearby Contract	.741	.651*
3 to 6 Month Contract	.571	.427*
6 to 9 Month Contract	.406	.242*
9 to 12 Month Contract	.369	.228*
Wheat (21 observations)		
The Nearby Contract	.918	.917
2 to 6 Month Contract	.921	.862*
4 to 8 Month Contract	.909	.840*
6 to 10 Month Contract	.887	.843*
Corn (21 observations)		
The Nearby Contract	.725	1.021
2 to 6 Month Contract	.666	1.011
4 to 8 Month Contract	.608	.969
6 to 10 Month Contract	.560	.887

* Significantly different from 1 at .05 level.

results in Tables 1 and 2 are certainly consistent with the hypothesis that e will be larger for the longer hedges. This difference in hedging effectiveness appears particularly pronounced for the financial security futures.

The hypothesis that short-term hedges in nearby contracts are more effective than hedges in more distant contracts appears to hold for all except the GNMA market.

In estimating e we also estimated b^*.[8] These estimates, which are also reported in the Tables, are themselves of interest since traditional theory implies that $b^* = 1$. In most cases b^* was significantly different from 1 and in general was less than 1. The hypothesis that $b^* = 1$ is therefore rejected.

Since these are ex-post estimates of b^* and since hedgers may be unable because of the individuality of the futures contract to achieve the desired b, the question of the sensitivity of e to the chosen b is one of some importance. To address this question, we calculated e or r^2 for b's ten percent greater and lower than those shown in Tables 1 and 2. For hedges in either GNMA's or T-Bills, in either the nearby or the next closest contract, and over either a two or four week period, raising or lowering b ten percent from the estimated b^* resulted in a reduction in e of approximately 1%. We conclude, therefore, that these results are not very sensitive to small deviations in b.

[8] Let us note again that hedgers in T-Bills must adjust these estimates of b^* to reflect the term to maturity and the hedging period of their own portfolio.

While real cross-hedging was not considered, the effectiveness of the GNMA futures market in hedging positions in 6½% and 9% certificates was examined. As mentioned earlier, one can deliver these certificates to satisfy a futures contract and an earlier study (Ederington and Plumly, 1976) indicated that, at least in 1976, it would have been cheaper to deliver 9% certificates than 8% certificates and more expensive to deliver 6½% certificates. For this reason we expected e to be higher for 9% than for either 8 or 6½% certificates. This proved to be the case for all two-week hedges. Indeed, for all futures contracts e was highest for a hedge against 9% certificates, lower for 8% certificates, and lowest for 6½% certificates. For hedges in the nearby contract over a two week period, for instance, the measures of e were .820, .664, and .662 respectively.

Having found that, at least for GNMA's, one can lower the risk (as measured by the variance) associated with holding securities by holding futures, attention is now turned to the impact of hedging on expected returns. Two points are clear from equation 7. One, expected returns are lowered by the amount of the brokerage and other costs associated with the futures. Two, if the expected change in the basis is zero and $0 < b < 1$, partial hedging reduces the gain or loss associated with an unhedged position $\{X_s E(S)\}$. Attention is therefore centered on the term, $E(\Delta B)$. The important question is whether over the long run $E(\Delta B)$ will tend to be consistently negative or positive i.e., whether the expected value of the expected change in the basis is positive or negative. Since the basis must be approximately zero at the delivery date,[9] $E(\Delta B)$ will generally be positive if the current cash price exceeds the current futures price and will generally be negative if the futures price exceeds the cash price.

The longer the hedge and the closer the delivery date, the closer this relationship between $E(\Delta B)$ and the initial basis should be. The question basically reduces, therefore, to whether there is any reason to anticipate that in the long-run futures prices will generally be above or below cash prices.

Over the observed period, cash prices on GNMA's and T-Bills consistently exceeded futures prices (except occasionally at delivery). To provide an idea of what changes in the basis might have been expected during this period, the average change in the basis as a percent of the cash price (for comparison) was calculated for four week hedge periods.[10] The results are shown in Table 4.[11] As expected, the average change in the basis was positive so that over this period the change in the basis tended to add to (subtract from) the expected returns of those taking a long (short) position in the futures market.[12] In addition, it is interesting to note that for GNMA's the average change in the basis tended to vary inversely with the length of the futures contract. Since the risk reduction

[9] If it is cheaper to deliver GNMA certificates with a mortgage rate other than 8%, the basis for GNMA's will not be eliminated completely. A negative basis remains depending on the difference in costs.

[10] The average change for four weeks is not exactly double the change for two weeks because the periods do not completely overlap since periods in which the nearby contract matured were eliminated.

[11] The author does not feel that corn and wheat provide a meaningful comparison in this case because the basis on these varies with the time till harvest and storage costs.

[12] Note that when the basis is negative, those who take a long position in the futures market and take delivery lock in the lower buying price and higher interest rate. Those who are short and make delivery lock-in a selling price which is below the current selling price.

Table 4

Average Change in the Basis
Over 4 Week Periods
January 1976 (March for T-Bills)—December 1977

Futures Contract	Average Change in the Basis as a % of the Cash Price: GNMA Certificates	Treasury Bills
The Nearby Contract	.271%	.184%
3 to 6 Month Contract	.162%	.220%
6 to 9 Month Contract	.133%	.161%
9 to 12 Month Contract	.098%	.164%

was approximately the same for all four contracts, this suggests that long (short) hedgers would have been well advised to hedge in the nearby (distant) contract.

While over the observed period cash prices on GNMA's and T-Bills consistently exceeded futures prices so that positive changes in the basis could generally be expected, this was not always the case in 1978 and may not be the case in the future. The author is much more reluctant to accept Table 4 as a guide to the future than Tables 2 and 3. The crucial question is whether futures prices are unbiased measures of market expectations of future spot rates or whether they are biased downward by "normal-backwardation." There isn't enough data to answer this question since the lower futures prices to date could simply reflect consistent expectations of rising interest rates.

There continues to be a theoretical and empirical debate over "normal backwardation," the Keynes-Hick argument from which the liquidity premium theory of the term structure was developed.[13] However, it is questionable whether evidence from other futures markets is applicable to GNMA and T-Bill markets. Hick's argument [8, pp. 136–139] was that most hedgers of agricultural commodities maintain a long position in the cash and a short position in the futures market so that there is a weakness on the demand side of the futures market which speculators will not step in and absorb until the futures price is sufficiently low so that the expected favorable price change will compensate for the risk. Since it is an open question whether hedgers in GNMA's and T-Bills are generally long or short, the existence and sign of any liquidity premium in these markets is less certain.

For the T-Bill market there is an additional consideration. Since one can satisfy the delivery commitment by delivering longer T-Bills on which all but three months have elapsed, the possibility of riskless arbitrage should theoretically keep the futures rates close to the forward rates implicit in the term structure.[14] If, therefore, there are liquidity premiums in the term structure they should be reflected in the futures market. While there is still debate on this point, the bulk of recent evidence indicates that the term structure does contain liquidity premiums [7 and 9]. For T-Bills, therefore, it may be that futures prices normally tend to be below cash prices so that $E(\Delta B)$ is generally positive.

[13] See Peck, Section 1 [4], Burger, Lang and Rasche [3], Fama [7], and Cornell [4].

[14] While this should theoretically be the case, surprisingly large differences between future and forward rates have been observed [2].

III. Conclusions and Observations

The conclusions of this study may be summarized as follows:

1. The decision to hedge a cash or forward market position in the futures market is no different from any other investment decision—investors hedge to obtain the best combination of risk and return. Basic portfolio theory, which best explains when and how much holders of financial portfolios will wish to hedge, encompasses both the traditional hedging theory and Working's theory as special cases.
2. The implication of many "How-To" articles in the popular financial press that hedges in GNMA's and T-Bills are perfect because cash and futures prices change by equal amounts is completely indefensible.
3. Contrary to traditional hedging theory (but consistent with the theory of adaptive expectations), our empirical results indicate that even pure risk-minimizers may wish to hedge only a portion of their portfolios. In most cases the estimated b^* was less than one.
4. Based on the experience to date, the GNMA futures market appears to be a more effective instrument for risk avoidance than the T-Bill market particularly for short-term (i.e., two-week) hedges.
5. Both the GNMA and the T-Bill market appear to be more effective in reducing the price change risk over long (four-week) than over short (two-week) periods.
6. While changes in the basis were generally positive over the observed period (adding to the return on long hedges and subtracting from that on short hedges), the financial futures markets have not been in existence long enough to tell whether this is the usual case because of "normal backwardation" or whether it merely reflects expectations during the observed period.

A number of unanswered questions and topics for future research regarding futures markets in financial securities obviously remain. One which the author regards as particularly important is the effectiveness of the new futures markets for cross-hedging, i.e., for reducing the risk of portfolios containing securities other than GNMA's or T-Bills. Since mortgage lenders must often commit themselves months before the funds are lent, the effectiveness of the GNMA future in hedging against changes in conventional mortgage rates (or in the cost of funds) seems to be an important unanswered question. [However, our results are appropriate if the lender plans to finance the mortgages by issuing GNMA Pass-Through Certificates as in Table 1.] Unfortunately, the only data series for local mortgage rates of which the author is aware—the Federal Home Loan Bank Board series—measures the rate on loans made and these loans may reflect commitments made months ago. What are needed are localized data on new commitments.

REFERENCES

1. P. W. Bacon, and R. E. Williams, 1976. "Interest Rate Futures: New Tool for the Financial Manager," *Financial Management* (Spring, 1976), pp 32–38.
2. B. Branch, 1978. "Testing the Unbiased Expectations Theory of Interest Rates." Paper presented at 1978 annual meeting of the Eastern Finance Association.
3. A. E. Burger, R. W. Lang, and R. H. Rasche, 1977. "The Treasury Bill Futures Market and Market Expectations of Interest Rates," *Review* of the Federal Reserve Bank of St. Louis, Vol 59, No. 6, pp 2–11.

4. Bradford Cornell, 1977. "Spot Rates, Forward Rates and Exchange Market Efficiency," *Journal of Financial Economics* (August, 1977), pp 55–60.
5. W. H. Duncan, 1977. "Treasury Bill Futures—Opportunities and Pitfalls," *Review* of the Federal Reserve Bank of Dallas (July, 1977).
6. L. E. Ederington, and W. E. Plumly, 1976. "The New Futures Market in Financial Securities," Futures Trading Seminar Proceedings, Vol IV, Chicago Board of Trade.
7. E. F. Fama, 1976. "Forward Rates as Predictors of Future Spot Rates," *Journal of Financial Economics* (Oct., 1976), pp 361–378.
8. J. R. Hicks, 1946. *Value and Capital* (London: Oxford University Press) second edition.
9. T. E. Holland, 1965. "A Note on the Traditional Theory of the Term Structure of Interest Rates on Three-and-Six-Month Treasury Bills," *International Economic Review* (September, 1965), pp 330–36.
10. S. F. Jacobs, and J. R. Kozuch, 1975. "Is There a Future for a Mortgage Futures Market," *The Mortgage Banker.*
11. L. L. Johnson, 1960. "The Theory of Hedging and Speculation in Commodity Futures," *Review of Economic Studies.* Vol 27, No. 3, pp 139–51.
12. J. B. Michaelsen, 1973. *The Term Structure of Interest Rates* (New York: Interest Educational Publishers).
13. J. H. McCulloch, 1975. "An Estimate of the Liquidity Premium," *Journal of Political Economy* (February, 1975), pp 95–119.
14. A. E. Peck, 1977. *Selected Writings on Futures Markets,* Vol II (Chicago: Board of Trade of the City of Chicago).
15. R. L. Sandor, 1975. "Trading Mortgage Interest Rate Futures," *Federal Home Loan Bank Board Journal* (September, 1975), pp 2–9.
16. B. Smith, 1976. "Trading Complexities, FHLBB Rules Impede Association Activity," *Savings and Loan News* (January, 1976).
17. J. L. Stein, 1961. "The Simultaneous Determination of Spot and Futures Prices," *American Economic Review,* Vol LI, No. 5.
18. N. A. Stevens, 1976. "A Mortgage Futures Market: Its Development, Uses, Benefits and Cost," *Review* of the Federal Reserve Bank of St. Louis (April, 1976).
19. L. G. Telser, and H. N. Higinbotham, 1977. "Organized Futures Markets: Costs and Benefits," *Journal of Political Economy* (October, 1977), Vol 85, pp 969–1000.
20. H. Working, 1953. "Futures Trading and Hedging," *American Economic Review* (June, 1953), pp 314–343.
21. ———. 1962. "New Concepts Concerning Futures Markets and Prices," *American Economic Review* (June, 1962), pp 431–459.