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ALTERNATIVE INSTRUMENTS FOR HEDGING INFLATION RISK IN THE BANKING INDUSTRY

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Alternative Instruments for Hedging Inflation Risk in the Banking Industry

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I. Introduction

The unprecedented volatility in inflation and interest rates experienced in this country over the past ten years and the subsequent failure and near failure of financial institutions has forced most bank and thrift executives to seek effective ways of hedging unexpected changes in inflation and interest rates. For example, bank and thrift executives can either use gap management or derivative market instruments to reduce their inflation risk exposure. The main purpose of this paper is to (i) discuss the relationship between inflation and capital market returns, and (ii) study the possible advantages of using consumer price index futures relative to other financial futures and cash market decisions in managing inflation-driven risk exposure for banking firms.

The idea that economic agents can convert fixed nominal payments into a constant flow of real purchasing power by linking currency units to a price index is not new (see Friedman (1984)). Indexed bonds and escalator wage clauses are two examples of these adaptions to the uncertainties of inflation. Interest in extensive indexation, however, appears only when inflation rates are high and variable. Lovell and Vogel (1973) were perhaps the first to realize the advantages of a distinct futures market based on a price level index.

Because futures contracts currently exist for a limited menu of commodities and financial instruments, the recent introduction of a consumer price index contract is a beneficial innovation; it provides a hedging vehicle for managing a risk element common in prices throughout the economy: uncertain inflation. "Homemade" indexation can now occur outside of bilateral negotiations. A consumer price index futures contract also permits a more efficient allocation of risk-bearing in the economy and could reduce the overall level of inflation risk exposure, if the market brings long and short hedgers together. Finally, a price index futures contract provides a market consensus on inflationary expectations that could be beneficial to both private and public decision-makers that are not direct market participants. For all of these reasons, the utilization and performance of the CPI-W futures contract merits evaluation, along with alternative methods of managing inflation risk.

This paper is organized as follows. Section II examines the relationship between the Treasury bill rate and inflation and the discusses impact of inflation on equity returns. Section III analyzes the impact of inflation on financial intermediary decisions and discusses the alternatives available to bank management for hedging inflation risk. Section IV develops a model for bank hedging of inflation risk. Empirical results are then used to illustrate our theoretical results. Finally, the conclusions are summarized in section VI.

II. The Relationship Between Treasury Bill Rates and Inflation

Since World War II, U.S. inflation has been generally rising, except for the last several years, and also fluctuating with increasing amplitude, as pointed out by Cagan (1985). Cagan's predicted and actual five-year average inflation rate is listed in Table 1. Hence, inflation risk management becomes

Table 1

Predicted and Actual Five-Year Average
Inflation Rates
(percent per year)

Prediction	Five-Year Average	Predicted Rate	Actual Rate	Error Predicted - Actual
1966	1967-71	3.98	4.48	-0.50
1967	1968-72	4.08	4.70	-0.62
1968	1969-73	4.88	4.96	-0.08
1969	1970-74	5.27	5.64	-0.37
1970	1971-75	5.87	6.38	-0.51
1971	1972-76	6.08	6.42	-0.34
1972	1973-77	5.35	6.74	-1.39
1973	1974-78	5.41	7.05	-1.64
1974	1975-79	5.79	7.01	-1.22
1975	1976-80	6.48	6.99	-0.51
1977	1978-82	7.07	7.85	-0.78
1978	1979-83	7.52	7.18	+0.34
1979	1980-84	7.86	6.26	+1.60
1980	1981-84[a]	7.85	5.63	+2.22
1981	1982-84[b]	7.90	4.44	+3.46

[a]Four year average.
[b]Three year average.

Note: Based on annual average of GNP deflator and M1. Predictions of regressions of inflation rate on annual monetary growth for four preceding years, 1953 to year prediction is made. The prediction from the regression uses data of actual monetary growth for the four years prior to the predicted year.

Source: Phillip Cagan (1985), "The Unpredictability of Inflation" MIMEO.

important for equity and bond investing, mutual fund managers, pension fund managers and banking executives. There are commodity futures, financial futures and options that can be used by inventors and managers to hedge this inflation risk, albeit imperfectly. Inflation will generally increase interest rates and affect the market value of equity. First, examine the impact of inflation on interest rates.

Irving Fisher (1930) pointed out that the one-period nominal rate of interest is the equilibrium real return plus the fully anticipated rate of inflation. Roughly speaking, the nominal rate of interest can be thought of as the sum of the equilibrium expected real return and the market's view of the expected inflation rate.

Fama (1975) tested the relationship between nominal interest rates on default-free bonds and price level changes. As such he was the first to test the relationship on an ex ante basis. His conclusions were that:

1) expected real returns on Treasury Bills were constant during the testing period, and

2) the capital markets are efficient in setting the price of the bills since the nominal rates summarize all the information about future rates of inflation that is in the time series of past rates.

These conclusions have drawn some criticism. Carlson (1977) used survey data on inflation expectations to discount the first conclusion. He found that the short-term expected real rate fell during recessions. Further, he found that interest rates were not efficient predictors of inflation because information about inflation was also provided by an additional variable, the ratio of employment to population. Using an information set broader than the past history of the CPI, Joines (1977) concludes that the market is concerned about forecasting a more general index of inflation. Further, the lack of monthly sampling of all items in the CPI is a deficiency in the data.

Nelson and Schwert (1977) showed that the autocorrelation function of the ex post real rate of interest may be quite close to zero at all lags, even if the ex ante real rate varies substantially and is highly autocorrelated. They showed, using a univariate ARIMA model of the rate of inflation, that the coefficient of the predictor is large and significant in a composite prediction regression equation which includes the market interest rate. This should only occur if the market is inefficient in assimilating information contained in past inflation rates. By making more efficient use of the information about future inflation contained in past rates, Nelson and Schwert were able to reject Fama's hypotheses.

Hess and Bicksler (1975) also concluded that the behavior of nominal interest rates on Treasury bills is not consistent with the joint market efficiency and real rate constancy hypothesis. Furthermore, the failure to confirm market efficiency appeared to be the result of naive estimates of the expected real rate.

Fama (1977) countered that all these challenges do not imply rejection of the joint hypothesis over the 1953-71 period for the Treasury bill market. He found that the interest rate remained the best (if not the sole) single predictor of the inflation rate. Although not an exact description of the actual market, the specific deviations were mostly manifestations of measurement errors in the estimates of the different rates.

Following Fama (1975, 1977), we have the basic Fisher relationship

(1) $$R_t = \tilde{r}_t + \tilde{\Delta}_t,$$

where $\tilde{r}_t$ and $\tilde{\Delta}_t$ are random variables with $\tilde{r}_t$ = the real return in month t, $\tilde{\Delta}_t$ =

the inflation rate at end of month t-1, and R_t = the nominal interest rate quoted at end of month t-1 on a Treasury bill that matures at the end of month t.

The market's expectation about inflation will depend on the difference between the nominal rate and the market's expectation about the real return,

$$(2) \qquad E_m(\tilde{\Delta}_t|\phi^m_{t-1}) = R_t - E_m(\tilde{r}_t|\phi^m_{t-1}, R_t) = R_t - E(\tilde{r}_t),$$

where $E_m(\tilde{\Delta}_t|\phi^m_{t-1})$ = the market's expected inflation rate based on a prior information set used by the market, $E_m(\tilde{r}_t|\phi^m_{t-1}, R_t)$ = the market's expected real return based on prior information and the current nominal rate, and $E(\tilde{r}_t)$ = the expected value of the real return on the bill for the month. This becomes a testable hypothesis via the linear equation.[1]

$$(3) \qquad \Delta_t = \alpha_o + \alpha_1 R_t + \varepsilon_t.$$

If Fama's hypotheses are correct the intercept term should be postive and significantly diffrent from zero ($\alpha_o = E(\tilde{r}_t) > 0$) and the slope should be insignificantly different from minus one ($\alpha_1 = -1$). Fama found these estimates in terms of monthly data to be α_o = .00068 (t ratio = 2.27) and α_1 = -.978 (t ratio = -9.59) using 1953-71 data.

In updating Fama's research, data for two subperiods, 1959-1971 and 1972-1986, were used to estimate equation (3). The results are listed in Table 2. Table 2 indicates that the relationship between inflation and the three-month Treasury bill rate for the period 1972 - 1986 does not follow Fama's hypotheses, although empirical results from 1959 - 1971 do conform.

Table 2

OLS results for $\Delta_t = \alpha_o + \alpha_1 R_t$

Data Period	α_o	α_1	$\bar{R}^2$	D.W.
1959-1971	0.0037* (3.021)	-1.009* (-9.316)	0.6273	1.621
1972-1986	-0.0125* (-3.646)	-0.2028 (-1.310)	0.0124	0.475

Note: Values within parentheses are t statistics.
*Significantly different from zero at the 5% level.

Table 3

OLS results for $\Delta_t = \alpha_o + \alpha_1 R_t + \alpha_2 \Delta_{t-1}$

Data Period	α_o	α_1	α_2	$\bar{R}^2$	Durbin h
1959-1971	0.0026* (2.018)	-0.7316* (-4.062)	0.2648** (1.858)	0.6454	a
1972-1986	-0.0059* (-2.611)	0.1768** (1.690)	0.8610* (9.431)	0.6158	0.2384

Note: Values within parentheses are t statistics.
[a]Durbin h test for autocorrelation not valid.
*Significantly different from zero at the 5% level.
**Significantly different from zero at the 10% level.

To examine the existence of inefficiency in the Treasury bill market, we add a lagged inflation variable to equation (3) and obtain

(4) $$\Delta_t = \alpha_0 + \alpha_1 R_t + \alpha_2 \Delta_{t-1} + \varepsilon_t$$

If the estimated α_2 is significantly different than zero, then there exists inefficiency in the Treasury bill market. Empirical results for equation (4) are listed in Table 3. It is shown that the estimated α_2's are significant at the 10% and 1% levels for the period 1959-1971 and the period 1972-1986, respectively. These results imply that equation (3) for 1972-1986 is misspecified.

To investigate the potential impact of the change in Federal Reserve policy on October 6, 1979, as a source of misspecification for the inflation and Treasury bill rate relationship, both an intercept dummy and a slope dummy are added to equations (3) and (4). On this date, the Federal Reserve System changed their monetary policy operating procedure from targeting the federal funds rate to targeting a monetary aggregate (nonborrowed reserves). Under the new regime, short-term interest rates were allowed to seek an equilibrium level consistent with the availability of funds in our financial system. This change in operating procedure could be one reason for the breakdown in the inflation-Treasury bill rate relationship for 1972 - 1986 noted above. We then obtain

(5) $$\Delta_t = \alpha_0 + \alpha_1 R_t + \alpha_2 D_t + \alpha_3 D_t R_t + \varepsilon_t$$

(6) $$\Delta_t = \alpha_0 + \alpha_1 R_t + \alpha_2 D_t + \alpha_3 D_t R_t + \alpha_4 \Delta_{t-1} + \varepsilon_t$$

where D_t = 0 for 1972 to the third quarter 1979, and

= 1 for the 4th quarter 1979 to the third quarter 1986.

Estimation results for equations 5 and 6 over the 1972-1986 period are presented in Table 4. Table 4 indicates that there is an impact of the 1979 Federal Reserve policy change on the relationship between the inflation rate and the Treasury bill rate. These results also imply that Fama's hypotheses as indicated in equation (3) cannot adequately describe the current relationship between the inflation rate and the Treasury bill rate.

The results above have important implications for using three-month Treasury bill futures to hedge inflation-driven interest rate risk in the banking industry. Inflation will generally have an impact on the market values of assets, liabilities, equity and profits of commercial banks. If the relationship between the inflation and Treasury bill rate follows Fama's hypothesis, then Treasury bill futures can be effectively used by decision-makers to hedge short-run inflation risk. If the relationship does not follow Fama's hypothesis, then Treasury bill futures will not necessarily be useful for hedging inflation risk. Other financial futures contracts or the recently introduced CPI-W futures contract may be better candidates for an effective hedging instrument.[2]

Next examine the impact of inflation on the market value of equity. This topic has been extensively examined by Roll (1973), Merton (1973), Chen and Bones (1975), Friend, Landskroner and Losq (1976), Jaffe and Mandelker (1976), Chu et al. (1985), Elton et al. (1983), Gultekin (1983), Lee et al. (1985) and others. Lee et al. (1985) found individual equity returns can be either postively or negatively related to the inflation rate. However, Jaffe and Mandeker (1976) and Lee et al. (1985) have also found that rates of return on stock indexes are generally negatively related to the inflation rate. The theoretical value of a stock index can be written as

$$(7) \qquad I_t = \sum_{t=1}^{\infty} \frac{d_o (1 + g)^t}{(1 + k)^t}$$

Table 4

OLS results for equations (5) and (6), 1972 - 1986

Coefficient	Equation (5)	Equation (6)
α_0	0.0045 (0.905)	0.0002 (0.047)
α_1	-1.4842* (-4.894)	-0.3407 (-1.097)
α_2	-0.0023 (-0.303)	-0.0071 (-1.194)
α_3	0.8864* (2.427)	0.5085** (1.719)
α_4	-	0.7546* (5.792)
$\bar{R}^2$	0.3991	0.6251
D.W.	1.294	-
Durbin h	-	1.125

Note: Values in parentheses are t statistics.
*Significantly different from zero at the 5% level.
**Significantly different from zero at the 10% level.

where d_o = the initial dividend payment of the stock index, g = the growth rate associated with dividend payments, and k = the required rate of return.

Inflation will affect the market value of a stock index in terms of earnings, dividends and the discount rate. If the impact of inflation on I_t is essentially determined by k, then the correlation coefficient between I_t and the inflation rate should be negative. Most of the above-mentioned research finds that the ex post relationship between the inflation rate and rate of return on equity is negative. However, Gultekin (1983) found that expected real equity returns from the S&P 500 are postively correlated to expected inflation.

Cornell and French (1983) show that forward price of index futures can be defined as

$$F(t, T) = I(t) \{e^{r(T - t)} [1 - d/r] + d/r\} \quad (8)$$

where F(t, T) represents the forward price in period t with maturity T, I_t is the stock index, and r and d represent the interest rate and the dividend yield, respectively. If stock indexes are negatively related to inflation then index futures will be positively correlated with inflation. Therefore, stock index futures, along with debt instrument futures, and foreign exchange futures are potential instruments that can be used to hedge inflation risk in the banking industry.

III. The Impact of Inflation on Banking Firms

In a recent article, Landskroner and Ruthenburg (1985) investigate the optimal behavior of a commercial bank under uncertain inflation. This model of a risk averse, multiproduct, and price-discriminating intermediary reveals that an increase in uncertainty about the end of period inflation rate reduces total bank lending, lowers the deposit rate set by the bank, and induces the bank to shift the composition of assets and liabilities toward those linked directly to the inflation rate and away from those that are not linked to inflation. Inflation risk enters the model as a determinant of the profits from the nominal (non-linked) segment of the multiproduct bank. Other impacts of inflation on bank decision-making, such as the effect of disinflation on loan defaults and the effect of inflation on mismatched bank balance sheets, are not considered.

First consider the impact of disinflation on bank credit risks. If the bank's loan portfolio is not well diversified over all segments and industries in the economy, disinflation may affect the cash flows of bank borrowers and reduce their ability to service financial obligations. To the extent that the greater credit risk of the bank's loans are realized in actual loan defaults, the bank's return on earning assets is reduced, squeezing bank profits and the return on equity. On the other hand, if the bank's loan portfolio is well diversified, then losses due to default in one loan sector are offset by the increased credit worthiness of borrowers in another loan sector. Ex ante, the total loan returns are stabilized. Ex post with loan default, however, the increased credit worthiness of some of the bank's borrowers can not be internalized unless the loans are sold. If the lower credit risk loans are not sold, the defaulting borrowers again reduce the return on earning assets. If the lower credit risk loans are sold, asymmetric information about loan quality may prevent the bank from realizing the full value of the loans in the secondary market.

There are several cash market decisions that the bank can take to manage inflation-driven credit risk, if bank management expects disinflation. The bank could make fewer loans or increase its credit standards that determine qualified borrowers. To cushion the impact of loan write-offs, the bank could add to its equity capital. Futures market decisions could also prove useful, given a contract that accurately tracks the inflation rate. To protect against unanticipated disinflation and the loss of loan revenues, the bank could sell futures contracts. Should unexpected disinflation occur, futures profits could be used to augment bank cash market returns. It is also conceivable that the joint interaction of cash and futures market decisions could induce the bank to increase its inflation-driven credit risk by increasing nondiversified lending or lowering credit standards. As long as this risk can be transferred to the futures market, these decisions could help the bank maximize the expected utility of profits.[3]

There are other impacts of inflation on banking firms. Since banks are in the business of lending money, bank management may be interested in locking in high real rates of return on lending activities and preventing them from falling with unexpected inflation. The risk to the bank is that an unanticipated increase in inflation will erode the purchasing power of the funds lent out. The bank can counter this specific risk either by buying futures contracts whose prices move sympathetically with the inflation rate or by setting nominal loan rates higher than would be the case in the absence of inflation risk. However, except for a small amount of equity (usually in the neighborhood of 6% of total assets), nominal bank assets are funded by nominal debt liabilities. Therefore, the erosion of loan revenues due to inflation are offset almost completely by the erosion of funding (liability) costs. Since the financial intermediary is both a borrower and a lender, the bank's nominal profits are insulated from the realization of unexpected changes in inflation.

Of course, the offsetting impact of inflation is greatest when the maturity structure and repricing characteristics of each asset is exactly matched to each liability (called a zero maturity gap). If this is not the case and bank liabilities reprice or mature faster than bank assets (called a negative maturity gap), then inflation does have an impact on bank profits. The realization of unanticipated inflation raises market interest rates, increases the cost of funding bank assets, and squeezes the bank's profit margin. If bank assets reprice or mature faster than bank liabilities (called a positive maturity gap), then inflation has a favorable impact on bank profits and the risk in decision-making is that disinflation occurs. With a non-zero maturity gap, the bank can manage inflation risk either by asset and liability decisions that move the maturity gap toward zero or by futures market decisions that transfer the inflation risk to futures market participants.

What types of maturity gaps characterize U.S. commercial banks? The Federal Reserve collects quarterly maturity gap data on banks nationwide (Schedule J in the quarterly Report of Condition) and Table 5 is a summary of the data reported for June 1985. Table 5 reveals that negative maturity gaps for less than three months forward are the rule for all sized banks responding to the June 1985 Report of Condition. This data also tends to support the hypothesis that the larger the bank the smaller the maturity gap.[4]

With the above possible impacts of inflation on banking firms in mind, the next section of this paper presents a model of bank behavior with financial futures to investigate the management of inflation risk through joint cash and futures market decisions. Inflation risk enters the model by assuming different repricing characteristics of bank assets and liabilities, i.e., one of the bank's balance sheet items reprices faster than the rest of the balance sheet. A model of inflation-driven credit risk management by commercial banks is not explicitly treated.

Table 5
Summary of U.S. Commercial Bank Maturity Gaps
June 1985
(means with standard error of the mean in parentheses)

Bank Category	N	Gap 3	Gap 6	Gap 12	Gap 60
1. All banks	14,382	-0.0360*	-0.0126*	0.0413*	0.1835*
		(0.0012)	(0.0006)	(0.0006)	(0.0009)
2. Banks with assets less than $100 million	11,848	-0.0366*	-0.0109*	0.0437*	0.1834*
		(0.0014)	(0.0007)	(0.0007)	(0.0011)
3. Banks with assets $100-$500 million	2,044	-0.0362*	-0.0210*	0.0333*	0.1902*
		(0.0029)	(0.0012)	(0.0011)	(0.0023)
4. Banks with assets $500-$1000 million	198	-0.0274*	-0.0255*	0.0227*	0.1854*
		(0.0089)	(0.0038)	(0.0032)	(0.0093)
5. Banks with assets $1-$10 billion	268	-0.0199*	-0.0112*	0.0154*	0.1460*
		(0.0065)	(0.0022)	(0.0024)	(0.0060)
6. Banks with assets greater than $10 billion	24	-0.0230*	0.0020	0.0040	0.0720*
		(0.0094)	(0.0039)	(0.0031)	(0.0075)

Source: Report of Condition, June 1985.

Variable definitions:

Assets: total bank assets plus allowance for loan losses and minus goodwill.

Gap 3: Schedule J allocated assets maturing in three months or less minus liabilities maturing in three months or less (including Super NOW deposits and money market deposits) all divided by assets.

Gap 6: Schedule J assets maturing in three to six months minus liabilities maturing in three to six months all divided by assets.

Gap 12: Schedule J assets maturing in six months to one year minus liabilities maturing in six months to one year all divided by assets.

Gap 60: Schedule J assets maturing in one to five years minus liabilities maturing in one to five years all divided by assets.

N: Number of banks in category.

*Significantly different from zero at the 5% level.

IV. Hedging Inflation Risk

This section presents a model of interest rate risk management where the underlying source of the interest rate risk is an unanticipated change in the inflation rate. A position in the futures market is used jointly with earning asset rate-setting to hedge, ex ante, the uncertain cost of funds. That is, the futures hedge is an anticipatory hedge of a liability price risk faced by the financial intermediary. Hedging permits the separation of inflation risk considerations from gap management considerations in setting earning asset rates. Asset and liability management through financial futures hedging and rate-setting become tools for controlling risk exposure created by ex post liability management. This application of financial futures hedging is different than the literature on the anticipatory hedging of bank liability interest rates (see Franckle and Senchack (1982), Koppenhaver (1985), Parker and Daigler (1981), and Speakes (1983)) because it explicitly considers the management of the inflation risk faced by rate setting intermediaries. Furthermore, cash and futures market decisions are determined simultaneously.

It is assumed the bank uses two tools to manage the uncertainty of unanticipated inflation: trading futures contracts and setting earning asset interest rates. To manage an increase in the cost of funds, the bank can sell futures contracts and raise loan interest rates. The sale of futures contracts represents an anticipatory hedge of funding costs (a funding hedge) because it acts as an alternative source of funds. If inflation is closely associated with a rise in market intrest rates, the profits from a short (sell) futures position augment the increased cash market cost of funds. Bank profits can be sustained in the face of higher rates. Conversely, both lower inflation and lower market interest rates create less need for a funding hedge; the short position should be reduced or possibly changed to a long (buy) position to increase bank profitability. In conjunction with the funding hedge, the bank can raise (lower) loan interest rates to counter expected increases (decreases) in inflation, assuming a negative interest elasticity of loan demand.

Assume the bank has a one-period planning horizon. At the beginning of the period, the bank must decide on the futures position, X, and the earning asset interest rate, R_L. At this time, the bank knows the current futures price, P_X, the rate on retail deposits, R_D, and the loan demand schedule, $L(R_L)$, but does not know the interest rate on purchased funds, $\tilde{R}_B$, or the futures price, $\tilde{P}_X$, at the end of the period. (Tildes indicate random variables realized in the future.) When the purchased funds rate is realized and the futures position is offset, bank borrowing, B, takes place to fill out the balance sheet. The market for these funds is assumed to be perfectly competitive. Let $\tilde{R}_B$ be

(9) $$\tilde{R}_B = \tilde{r} + \tilde{\theta}, \text{ with } \partial R_B/\partial r \text{ and } \partial R_B/\partial \theta > 0$$

where r is the end of period real rate of interest and θ is the end of period expected inflation rate, both unknown ex ante but with a known subjective probability distribution. Bank profits (nominal) at the end of the period are given by:

(10) $$\tilde{\Pi} = R_L L(R_L) + (\tilde{P}_X - P_X)X - \tilde{R}_B B - R_D D$$

where D is the known level of retail deposits. For simplicity, initial margins and variation margin calls are ignored.

The bank's problem is to make two ex ante decisions, X and R_L, and one ex post decision, B, that will maximize the expected utility of profit subject to the balance sheet contraint at the end of the period.[5] These decisions are based on the bank's subjective expectation about future events, described by the joint cumulative density $F(\tilde{P}_X, \tilde{R}_B)$. It is assumed that this joint distribution does not change over the planning period. The decision problem can be written:

$$\text{(11)} \qquad \underset{X, R_L \geq 0 \quad B \geq 0}{\text{Maximize}} \; E[\max U(\tilde{\Pi}) \mid F(\tilde{P}_X, \tilde{R}_B)] \quad \text{subject to: } L = B + D$$

where E is the expectations operator, and U is a risk averse utility function such that $U'(\tilde{\Pi}) > 0$ and $U''(\tilde{\Pi}) < 0$ (a prime indicates derivation).

Assuming bank management is constant absolute risk averse and the joint distribution of random variables is normal, the objective function in expression (11) can be rewritten in a mean-variance expected utility framework, after substituting for B from the balance sheet contraint. Assuming no correlation between real rates and futures market prices and that loan demand is given by $L(R_L) = a_o - a_1 R_L$ with a_o, $a_1 > 0$, the optimal solution can be shown to be:

$$\text{(12)} \qquad X^* = \frac{E(\tilde{P}_X - P_X)}{\gamma \operatorname{Var}(\tilde{P}_X)} + \frac{[L(R_L^*) - D] \operatorname{Cov}(\tilde{\theta}, \tilde{P}_X)}{\operatorname{Var}(\tilde{P}_X)}, \text{ and}$$

$$\text{(13)} \qquad R_L^* = \frac{E\tilde{R}_B - (a_o/a_1)}{2 + \gamma a_1 \operatorname{Var}(\tilde{R}_B)} + \frac{(a_o - D) \operatorname{Var}(\tilde{R}_B) - X^* \operatorname{Cov}(\tilde{\theta}, \tilde{P}_X)}{(2/\gamma) + a_1 \operatorname{Var}(\tilde{R}_B)}$$

where γ is the index of risk aversion, Var represents variance, and Cov represents covariance.[6]

In the right hand side of equation (12), the optimal futures position is written as the sum of two terms: an expectations term and a risk exposure term. Initially, let the expectations term be zero. If the futures market moves in the same direction as inflation rates, $Cov[\tilde{\theta},\tilde{P}_X] > 0$. If the bank must purchase funds to support its lending, $(D - L(R_L^*)) < 0$, the optimal futures position represents a long hedge of the anticipated risk exposure. If inflation and higher interest rates occur, the profits from a long hedge substitute for the higher funding costs. A nonzero expectations term reinforces the incentive to take a long position if prices are expected to rise.

In the absence of futures trading, the solution to the model would be given by equation (13) with $X^* = 0$ in the second term on the right hand side. In the nonhedging solution, higher expected inflation and funding costs are managed by raising the loan rate; lower expected inflation and funding costs by lowering the loan rate. These qualitative effects are preserved when futures trading is introduced, but loan rates with an inflation hedge ($X^* > 0$) are lower than loan rates without hedging. Low loan rates may exacerbate the inflation risk in the bank's balance sheet; hedging the risk in the futures market makes low loan rates less risky. Alternatively, a large expected fall in inflation could result in a short futures position ($X^* < 0$ from equation (12)). Loan interest rates would then be set higher with futures trading than without futures trading. A short futures position offers no protection against higher purchased funding costs and is speculative; to compensate, loan rates must be raised to reduce the bank's exposure. Futures market risk is a substitute for funding market risk in maximizing expected utility.

Of course, if the bank should not need purchased funding, $(D - L(R_L^*)) > 0$, and invests this difference at R_B at the end of the period, the optimal futures position is a short hedge of the anticipated risk when the expectations term is small. This type of hedge offers protection against a fall in inflation and interest rates. If $X^* < 0$, then from equation (13), the optimal loan rate will be higher with rather than without futures hedging. With futures hedging, the higher loan rate rations loan demand and increases the amount to be invested at the end of the period, increasing the bank's exposure. In this case, the opportunity to shed risk via the futures market induces the bank to expand its cash market risk exposure in maximizing expected utility.

Before proceeding, note that if bank management is extremely risk averse ($\gamma \to \infty$), then the optimal solution in equations (12) and (13) becomes

(12') $$X^* = [L(R_L^*) - D] \, Cov(\tilde{\theta}, \tilde{P}_X)/Var(\tilde{P}_X), \text{ and}$$

(13') $$R_L^* = [(a_o - D)/a_1] - [X^* \, Cov(\tilde{\theta}, \tilde{P}_X)/a_1 Var(\tilde{R}_B)].$$

From equation (12'), the optimal hedge ratio, $X^*/[L(R_L^*) - D]$, is given by β_1 in the regression

(14) $$\tilde{\theta} = \beta_o + \beta_1 \tilde{P}_X + \epsilon,$$

where $\tilde{\theta}$ and $\tilde{P}_X$ are usually expressed as the changes in each respective variable. This result is well known (see Ederington (1979)) under these assumptions and will prove useful in the estimations below. In sum, bank decision-makers with an extreme aversion to risk will not employ expectations in simultaneous cash and futures market decisions.

V. Estimation of Hedging Strategies

This section estimates hedge ratios and hedging effectiveness for the CPI-W futures contract. To investigate the quantitative values of the optimal hedge ratio implied by equation (12'), equation (14) is our focus.[7] Of primary interest here is the optimal hedge ratio associated with the recently introduced CPI-W futures contract since this contract most closely fits the dependent variable in equation (14). The problem in estimating equation (14) is that observations on the actual CPI-W index are not reported daily, but only monthly, and with a lag, and at this writing only 15 values of the CPI index have been observed. Nevertheless, it would still seem worthwhile to estimate equation (14) using actual CPI index numbers and CPI-W futures data. Unfortunately, for hedging periods of less than one month, the estimated hedge ratio and hedging effectiveness using actual CPI index numbers might be misleading and inappropriate. A proxy for changes in inflation within a month is needed. Two different proxies are investigated here.

One proxy for $\tilde{\theta}$ in equation (14) can be constructed from section II of this paper. Recall from that earlier discussion that Fama's (1975) joint hypothesis does not hold using data from 1972-86. But from the estimated results for equation (5) in Table 4, $\alpha_1 + \alpha_3$ is an estimate of the marginal effect of a change in nominal Treasury bill rates on the ex post purchasing power of money. Assuming this relationship holds on a daily or weekly basis, a proxy for θ in equation (14) is $(\alpha_1 + \alpha_3)$ times the change in daily Treasury bill returns.[8] By substituting daily Treasury bill returns for $\tilde{\theta}$ in equation (14), the resulting β_1 could then be multiplied by $\alpha_1 + \alpha_3 = -0.6$ to approximate the optimal CPI-W futures contract hedge ratio.

The other inflation proxy used here is the change in the cash price of gold. As an actively-traded precious metal, gold price changes are sensitive to aggregate demand and supply conditions and have implications for the purchasing power of money. Indeed, recent articles in the popular press have called for using either the price of gold or an index of sensitive commodity prices as an intermediate target for monetary policy.

Using daily data from June 21, 1985, to September 29, 1986, for one- and three-month T-bill returns, gold prices, and the CPI-W futures market, equation (14) was estimated using ordinary least squares. The CPI-W futures series was constructed by using the near-term contract until the first day of the maturity month and then rolling over to the next most near term contract. Both the dependent and independent variables were expressed as percentage changes to adjust for different units of measurement.[9] The percentage changes in CPI-W futures prices, gold prices, and the cash CPI index were also recast in terms of the purchasing power of money, rather than the inflation rate, to facilitate computation of the CPI-W futures hedge ratio using the results in Section II.

Table 6 presents estimates of the coefficients in equation (14). Three different sets of regression results are reported for each of the inflation proxies based on three different hedge periods: daily, 14-day, and 28-day intervals. The results indicate that there is no statistically significant relationship between the interest rate proxies for inflation and CPI-W futures prices at any of the three different intervals. If one- and three-month T-bill returns reflect information about inflation, the CPI-W futures market does not reflect it, although the signs of β_1 are as expected. Cash gold price changes as an inflation proxy are reflected in CPI-W futures prices but only on the 28-day hedging period. In this case (line 3c, Table 6), gold prices and CPI-W futures prices move in the same direction and one cannot reject the hypothesis that the percentage changes are one-for-one. The release of actual CPI index numbers subsequent to contract maturity is

Table 6

Estimation of Equation (14) for Different
Dependent Variables, June 1985 - September 1986
(t ratios in parentheses)

Dependent Variable	β_0	β_1	R^2	DW[a]	ρ[b]	N[c]
1. Daily Returns on:						
a. One-month T-bills	0.00017*	-0.00024	0.0012	2.161	-	316
	(24.783)	(-0.603)				
b. Three-month T bills	0.00019*	-0.00015	0.0004	1.848	-	316
	(27.224)	(-0.373)				
c. Gold[d]	-0.00049	-0.01758	0.0013	2.351	-	281
	(-0.919)	(-0.610)				
2. Two-week Returns on:						
a. One-month T-bills	0.00018*	0.00008	0.0013	0.704	-	28
	(45.461)	(0.186)				
b. Three-month T-bills	0.00020*	-0.00011	0.0010	1.809	-	28
	(34.190)	(-0.161)				
c. Gold	-0.00712	0.89219	0.0676	2.638	-	21
	(-1.020)	(1.234)				
3. Four-week Returns on:						
a. One-month T-bills	0.00017*	-0.00014	0.0251	-	0.58057	13
	(21.752)	(-0.556)			(-2.762)	
b. Three-month T-bills	0.00020*	-0.00031	0.0874	-	-0.45570	13
	(29.676)	(-1.072)			(-1.983)	
c. Gold	-0.00947	1.43848**	0.2377	1.961	-	14
	(-1.050)	(1.934)				
d. CPI[e]	-0.00178	-0.01720	0.0093	-	-0.41942	13
	(-1.589)	(-0.336)			(1.789)	
e. Lag CPI	-0.00126**	0.10425**	0.2144	1.341	-	15
	(-1.951)	(1.884)				

*Significantly different from zero at the 5% level.
**Significantly different from zero at the 10% level.
[a]Durbin-Watson test statistic for autocorrelation.
[b]Estimate of first-order autocorrelation coefficient.
[c]Number of observations.
[d]Engelhard industrial billion.
[e]Consumer price index for all urban workers, not seasonally adjusted. Estimates based on calendar months.

not significantly related to CPI-W futures prices (line 3d, Table 6), but the release of the prior month's actual CPI index is reflected in the current futures price change (line 3e, Table 6). That is, CPI-W futures prices for the current month are positively related to the contemporaneous release of the new CPI index number that applies to the previous month. Given the lag in the release of actual CPI data, the CPI-W futures market utilities this information in revising expectations about the CPI index number to be realized at contract maturity.

In sum, CPI-W futures prices are not significantly related to short-term returns on Treasury bills or the subsequently released CPI index. To the extent that these instruments reflect changes in inflation, the CPI-W futures contract is a poor vehicle for hedging this risk. With gold prices as a indicator of inflation and over a four-week hedging period, the results here indicate that the optimal ratio of CPI-W futures contracts to exposure should be at least equal to 1. Little solace can be taken from the result that current CPI-W futures prices reflect the release of inflation data for prior months except that the market does react to new information, however irrelevant it might be for risk management today. The short-term inefficiency of the CPI-W futures market is probably a manifestation of the lack of open interest (rarely greater than 100 contracts for all maturity months) and thinness in the volume of trading since contract introduction. Whether the root problem is a overall lack of inflation over the data period or a flaw in contract design remains to be seen.

VI. Conclusions

This paper has empirially investigated the quality of information about inflation imbedded in cash market Treasury bill rates and found that Fama's (1975) joint hypothesis about the constancy of the real rate and the efficiency of the Treasury bill market do not hold for 1972-1985 data. This result may be due to the structural change that occured with the October 1979 shift in Federal Reserve policy. Once the Federal Reserve switched from pegging interest rates to pegging banking system reserves as a monetary control device, market determined interest rates lost much of their predictive power with respect to inflation.

This paper also discussed the impact of inflation on banking firm profitability, with particular emphasis on inflation driven credit and interest rate risks. A model of inflation-driven interest rate risk management was developed and the principal result from the model is that a risk averse bank would set nominal interest rates on loans lower with futures market hedging of inflation risk than without hedging. Using price data for the recently introduced CPI-W futures contract, estimates of the optimal hedge ratio that a bank might employ are not significantly different from zero for intervals of less than one month. Although the CPI-W futures has not attained sufficient open interest and trading volume to insure its long-run viability as of this writing, banks do have need for an instrument to hedge inflation risk and could be a market participant when the CPI-W futures market attains viability.

Footnotes

[1]Following Fama (1975), Δ_t is redefined here as the rate of change of the purchasing power of a unit of money (the reciprocal of the price level) instead of the inflation rate, as in equation (1).

[2]CPI-W futures were introduced by the Coffee, Sugar, and Cocoa Exchange and started to trade on June 21, 1985. This is a cash settlement contract that trades until the release of the actual index number for the CPI, approximately three weeks after the month for which the actual index applies.

[3]Bank management risk aversion is assumed to motivate the transfer of risk to those more willing to bear it. See footnote 5 below.

[4]This hypothesis is based on the observation that large banks are less reliant on retail deposits and better able to manage the term structure of their liabilities through purchased funds.

[5]For justification of expected utility maximization by banks, see the empirical studies by Edwards (1977) and Ratti (1980). This analysis also treats a bank's futures position as an off balance sheet item.

[6]A sufficient condition for the solution equations (12) and (13) is that the utility function demonstrate risk aversion. If real rates and futures market prices are correlated, the covariance terms in equations (12) and (13) are replaced by $Cov(\tilde{r},\tilde{P}_X) + Cov(\tilde{\theta},\tilde{P}_X)$. The solutions (12) and (13) could also be derived by assuming the real rate of interest is constant over the hedging period.

[7]Contrary to the theoretical model, this assumes that either: i) the loan rate is predetermined, or ii) that the loan rate is set in such a way that $X^*/[L(R^*_L) - D]$ varies only with $Cov(\tilde{\theta},\tilde{P}_X)/Var(\tilde{P}_X)$. In either case, the loan rate may not be set optimally.

[8]This follows by direct substitution into equation (5) for the proxy of inflation used here, assuming the intercept term is not significantly different from zero.

[9]The regressions that used the actual CPI index numbers as dependent variables were also estimated for level changes instead of percentage changes. Although not reported below, the results were not significantly different than those that are reported.

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