

# The Impact on Business Investment of the Federal Reserve System's Operating Procedures

By Dean W. Hughes and Duane Weimer

Over the past 30 years, the Federal Reserve System has used various approaches in conducting the nation's monetary policy. During the 1950s and 1960s, the System focused on controlling interest rates. In the 1970s and especially in the early 1980s, monetary authorities adopted operating procedures designed to control the growth of money and credit. Some have argued that this new focus on controlling money may have discouraged business investment and reduced the growth rate of the economy. According to this argument, as more emphasis has been placed on controlling the growth in money and credit, short-term interest rates have become more volatile. These fluctuations, in turn, may have increased the volatility and the level of long-term interest rates, which could have discouraged investment and lowered the nation's economic growth rate.

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If the new operating procedures of the Federal Reserve System do in fact result in less business investment and slower economic growth, then policymakers may want to consider alternative approaches to achieving monetary policy objectives. This article, therefore, examines the evidence of past interest rates and investment decisions to determine the validity of the argument that current techniques of monetary policy reduce investment and slow economic growth.<sup>1</sup> The first section of the article presents the main assump-

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<sup>1</sup> For another work in this area, see Lawrence Slifman and Edward McKelvey, "The New Operating Procedures and Economic Activity since October 1979," *New Monetary Control Procedures*, Federal Reserve Staff Study, Volume II, Board of Governors of the Federal Reserve System, February 1981. Slifman and McKelvey discuss only the impacts on investment of changes in the level of interest rates and output uncertainty induced by the new operating procedures. While they do not specifically look at the kinds of questions raised in this article, they do reach conclusions similar to those in this study. Given the short time between the October 1979 change in procedures and the time of their study, they could not find a difference in investment behavior which could be attributed to changes in the operating procedures of the Federal Reserve System.

tions of the argument which are then empirically tested in the next three sections. A summary of the major findings are presented in the final section.

## AN OVERVIEW OF THE ARGUMENT

The argument that the Federal Reserve's emphasis on monetary control results in reduced investment rests upon three assumptions.<sup>2</sup> First, it is assumed that the Federal Reserve adds to the volatility of both short-term and long-term interest rates by concentrating on controlling the growth of money and credit. Second, it is assumed that this greater volatility of interest rates discourages investment. And, third, it is assumed that volatile short-term interest rates increase the level of long-term rates, again discouraging investment.

Evidence relevant to the first point is obtainable because the operating procedures of the Federal Reserve System have changed twice since World War II.<sup>3</sup> Through the 1950s and 1960s, controlling interest rates served as the primary intermediate goal in the implementation of monetary policy. A change in the operating procedures occurred in the early 1970s when monetary authorities started considering both monetary aggregates and interest rates in conducting monetary policy. Then, in October 1979, the Federal Reserve decided to focus more closely on controlling the monetary aggregates and to accept wider movements in

interest rates. Over the years covered by these three periods, the operation of monetary policy clearly has been moving away from stabilizing interest rates.

If the first assumption is correct, recent variations in interest rates should be substantially greater than they were in the years when the Federal Reserve System attempted to keep interest rates stable. Standard statistical tests to see if this is the case form the basis of the analysis presented in the next section of the article.

The second assumption that volatile interest rates discourage investment is based on the argument that investors prefer stable rather than fluctuating profits. While other studies have assumed that the objective of investors is to maximize profits after interest expenses, avoiding fluctuations in profits (that is, avoiding risk) also could be important to them. For example, if business investors are the owners of the businesses, maintaining their standard of living might depend on a constant return on their equity. Accordingly, the third section of this article uses a standard model of business investment behavior, adjusted to incorporate a tradeoff between risk and return, to test the importance of fluctuations in interest rates in determining the level of investment.

The final assumption is that fluctuations in short-term interest rates cause the level of long-term rates to rise, thereby decreasing investment. Investors account for only the demand side of the credit markets. Savers are on the other side, supplying the funds used to finance investments. Thus, the motivations of savers are equally important in determining the level of interest rates. Consequently, if savers insist on higher interest rates on long-term securities when short-term rates fluctuate, the operating policies of the Federal Reserve could have an adverse impact on investment regardless of investors' sensitivity to fluctuating rates. Accord-

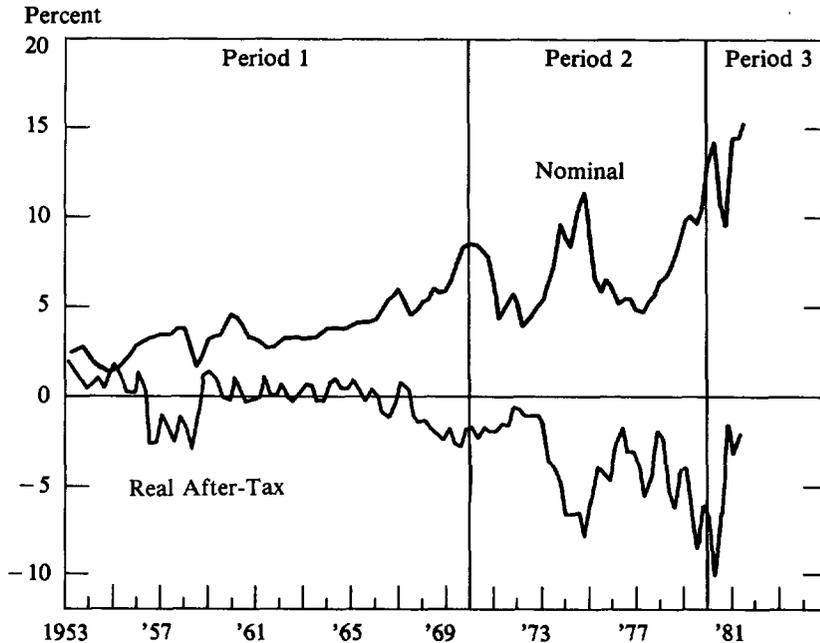
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<sup>2</sup> A distinction must be made between the impacts on investment of higher levels of interest rates and of greater volatility in interest rates. Higher levels of interest rates may be the temporary result of using monetary policy to fight inflation. These higher rates will undoubtedly decrease investment if all else is the same. This article, however, focuses on the less certain implications of the attempt to control monetary aggregates.

<sup>3</sup> See Gordon Sellon, Jr., and Ronald L. Teigen, "The Choice of Short-Run Targets for Monetary Policy, Part III: An Historical Analysis," *Economic Review*, Federal Reserve Bank of Kansas City, May 1981, pp. 3-12.

**Chart 1**  
**NOMINAL AND REAL AFTER-TAX SHORT-TERM**  
**INTEREST RATES**

(Quarterly averages, 1953-81)



ingly, tests are conducted in the fourth section of the article to determine whether there is a connection between variations in short-term interest rates and the level of long-term interest rates.

**FEDERAL RESERVE OPERATING  
PROCEDURES AND INTEREST  
RATE VOLATILITY**

This section examines whether the volatility of interest rates has risen as the operating procedures of the Federal Reserve have shifted increasingly to controlling the monetary aggregates. Tests are made for both nominal and real after-tax costs of financing business investments. Real after-tax as well as nominal in-

terest rates are used because the impacts of taxes and inflation are components in investment decisions. Long-term as well as short-term rates are considered because long-term interest rates are normally used in explaining investment decisions, although monetary policy initially affects only short-term rates.<sup>4</sup>

Chart 1 plots both a nominal short-term interest rate and a real after-tax short-term in-

<sup>4</sup> See for example, D. W. Jorgenson, "Capital Theory and Investment Behavior," *American Economic Review*, Vol. 53, May 1963, pp. 247-59; Frank DeLeeuw, "The Demand for Capital Goods by Manufacturers: A Study of Quarterly Time Series," *Econometrica*, Vol. 30, July 1962, pp. 407-23; or Patric Hendershott and Sheng-Cheng Hu, "Investment in Producers' Equipment," *How Taxes Affect Economic Behavior*, Brookings Institute, 1981, pp. 85-129.

terest rate for the 1953-81 time period.<sup>5</sup> The interest rate on dealer-placed, 4- to 6-month commercial paper is used to represent the short-term nominal interest rate. The real after-tax short-term rate is defined as equal to the nominal after-tax commercial paper rate minus the annualized inflation rate over the previous six months. The nominal after-tax rate is equal to the nominal rate multiplied by one minus the maximum corporate profit tax rate. Chart 1 is separated into three time periods corresponding to the three periods of different Federal Reserve System operating procedures. The first period, 1953 through 1969, spans the time when monetary authorities concentrated on controlling interest rates. The second period, 1970 through September 1979, covers the time during which the Federal Reserve System followed a mixed operating procedure, attempting to control both interest rates and monetary growth. During the third period, October 1979 through June 1981, the primary focus of operating monetary policy was on controlling growth in money and credit.

Chart 1 shows that short-term nominal interest rates followed an increasing trend over the entire time period, growing from slightly over 1 percent in 1955 to over 15 percent in 1981. Short-term real after-tax interest rates, however, were generally negative and declining. In both cases, though, variations of these interest rates increased over time, and the changes in volatility correspond reasonably well with changes in the operating procedures of the Federal Reserve System.

Long-term rates are plotted in Chart 2. The long-term nominal interest rate is the Standard

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<sup>5</sup> Although monthly observations are used in the following analysis of variances, charting monthly observations for 28-1/2 years is cumbersome and adds little to the intuitive insights derived from a chart. All charts, therefore, show quarterly average interest rates. The starting date of 1953 is used, rather than 1951, because moving 12-month variances are used later in this research.

and Poor's interest rate on Aaa corporate bonds. The long-term real after-tax rate is a measure of the real after-tax cost of capital, constructed as a weighted average discount rate that includes the cost of both debt and equity and is invariant to inflationary expectations.<sup>6</sup> As Chart 2 shows, long-term rates do not show the same patterns as short-term rates. While the nominal long-term rate increased over time, as did the nominal short-term rate, the real after-tax long-term rate did not decline over time as did the real after-tax short-term interest rate. It is also not evident that the volatility of long-term rates increased over time as did the volatility of short-term rates.

Visual inspection alone, however, cannot establish the relative volatility of interest rates during different time periods. A more precise way to compare volatilities of interest rates among the three time periods is to compute a variance of each of the interest rates for each time period. A variance is a measure of how often and by how much a series of observations differs from its average level.<sup>7</sup>

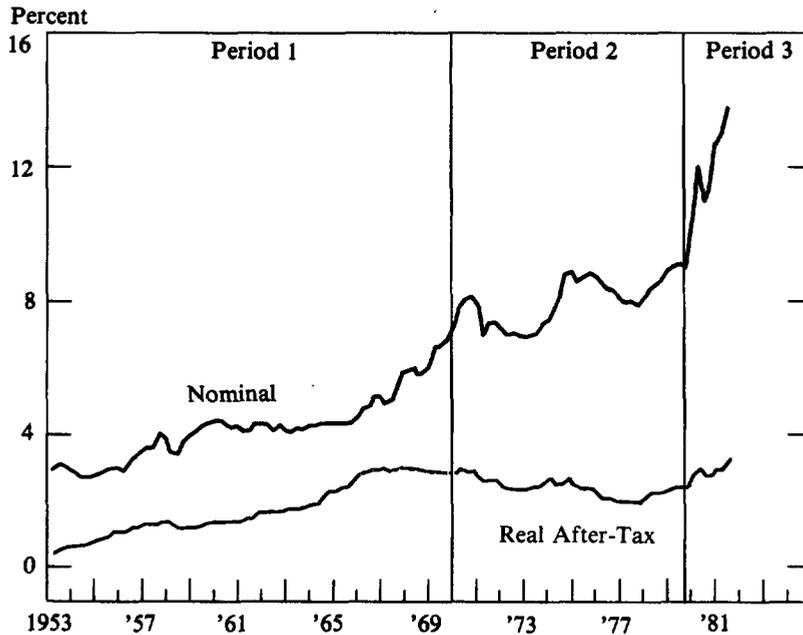
Table 1 presents variances of the four financing rates in each of the different time periods. The variances of the short-term interest rates are shown to have increased over time. For example, the variance of the nominal commercial paper rate rose from 3.08 in the 1953-69 period

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<sup>6</sup> The procedure followed in developing this series is detailed in Hendershott and Hu. Their methodology assumes that a weighted average cost of debt and equity is used to discount future profits of an investment. Inflationary expectations add to the nominal interest rate paid on debt and reduce the return on equity. Given their way of calculating a discount rate, these two influences cancel each other. Thus, the level of the average cost of capital does not depend on how fast people expect prices to increase.

<sup>7</sup> More precisely, the variance of a time series is the sum of the squared differences from the average of the series divided by the number of observations less one. An alternative measure of volatility, the variance of the series after removing the time trend during each period, was also calculated, but did not substantially alter the conclusions reached using simple variance.

**Chart 2**  
**NOMINAL LONG-TERM INTEREST RATE AND**  
**REAL AFTER-TAX COST OF CAPITAL**  
 (Quarterly averages, 1953-81)



to 4.43 during the 1970s. A further increase occurred after October 1979, although it was not statistically significant. Also, increases occurred in each of the different time periods for the short-term real after-tax interest rate. The evidence, therefore, shows that the volatility of short-term interest rates increased as the operating procedures of the Federal Reserve System increasingly concentrated on controlling the growth of money and credit.<sup>8</sup> There

<sup>8</sup> Dana Johnson reaches somewhat similar conclusions in "Interest Rate Variability Under the New Operating Procedures and the Initial Response in Financial Markets," *New Monetary Control Procedures*, Federal Reserve Staff Study, Volume I, Board of Governors of the Federal Reserve System, February 1981. Using daily and weekly rates, Johnson finds statistically significant increases in

are, of course, many other things that have an impact on the variability of interest rates, particularly changes in the underlying determinants of the demand for money and the

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nominal interest rate volatility between a time period roughly equivalent to our period 2 and the post-October 1979 period. It is possible that the addition of the first half of 1981, when interest rates were relatively stable and not influenced by the introduction of credit controls, could account for the lack of significance reported in Table 1. It is considered more likely, however, that the loss of precision due to using monthly averages accounts for the somewhat different results in comparing nominal interest rate fluctuations in this article. Unfortunately, Johnson's calculations do not cover the 1950s or 1960s, so no comparison of current volatility to those periods was possible. His calculations also lacked any reference to real interest rates and, therefore, cannot be used to corroborate the findings of this article.

money multiplier. Yet the Federal Reserve's supply of reserves to the banking system must be considered an important determinant of both the level and the variability of short-term interest rates.

The variances of longer term rates, however, tell quite a different story. Instead of increasing over time, the variance of nominal and real after-tax long-term rates declined during the 1970s. Moreover, while the variance of the nominal long-term interest rate increased

significantly after October 1979, the variance of the real cost of capital showed only a small increase. Thus, it is not clear that monetary authorities caused long-term rates to become more volatile by allowing short-term rates to fluctuate. In fact, given the rather dramatic decline in the volatility in long-term rates during the 1970s, it could be argued that a mixed operating procedure, which gives weight both to controlling growth in money and credit and to controlling short-term interest rates would be most conducive to long-term interest rate stability.

**Table 1**  
**THE VARIANCES OF SHORT-TERM AND LONG-TERM MONTHLY FINANCING RATES FOR SELECTED TIME PERIODS**

Variable	Period 1 1953-69	Period 2 1970- September 1979	Period 3 October 1979- June 1981
Short-Term Commercial Paper:			
Nominal	3.08	4.43*	6.57†
Real After-Tax	1.75	5.15*	9.50*
Long-Term Rates:			
Aaa Corporate Bonds	1.77	0.51*	1.80*
Real cost of Capital	0.64	0.04*	0.06†

\*For these variances, the change from the previous period is statistically significant. The statistical test used here is called an F-test, which tests to see if the ratio of variances is significantly different from one. The test takes into account the size of the difference between the variances, the number of observations in the different time periods, and the degree of confidence desired. A level of confidence of 95 percent was used in this study.

†For these variances, the change from the previous period is not statistically significant.

Note: Interest rates are measured in percentage terms. Period 1 contains 216 months, Period 2 contains 106 months, and Period 3 contains 22 months.

### THE IMPACT OF INTEREST RATE VOLATILITY ON INVESTMENT

This section examines the determinants of investment in order to test the hypothesis that investors are deterred by volatile long-term interest rates. The important aspects of a standard model of investment behavior are presented first. The model is then extended to account for the possibility that investors may want to avoid fluctuations in profits after interest expenses. Finally, the results of statistically estimating both the standard and the adjusted models are presented.

#### The Standard Model

The central aspects of most models of investment behavior can be conveyed using only three relationships. The first relationship is between investment and the gap between the optimum and actual levels of capital. The second relationship explains the optimal level of capital, while the third relationship combines the first two.

In specifying the first relationship, most investment studies agree that investment expenditures are made only when there is a gap between an optimal level of capital stock, which is

the amount of capital needed to maximize profits, and currently existing capital stock.<sup>9</sup> These studies also agree that the gap is not closed in any one time period, particularly when the time periods are as short as those used in this study. It is possible to capture this relationship in an equation of the following form:

$$(1) NI_T = \theta(t)(K_t^* - K_{t-1}),$$

where  $NI_T$  = the net investment that occurs during time period T,

$K_t^*$  = the optimal capital stock at the end of the time period,

$K_{t-1}$  = the actual capital stock at the beginning of the time period, and

$\theta(t)$  = the fraction of the gap between the optimal and actual capital stocks closed during time period T.

This equation states that net investment will be equal to a fraction,  $\theta(t)$ , of the difference between the optimal capital stock and the level of capital stock that existed at the beginning of the time period. The term  $\theta(t)$  is commonly called a partial adjustment coefficient and can be estimated using econometric techniques. Actually,  $\theta(t)$  represents coefficients on several past differences between the optimal and existent capital stocks. This representation assumes that many months are required to order, produce, ship, and install most durable goods and that long delays occur between the time that investors recognize the need for additional capital and the time that purchases are made.<sup>10</sup>

A commonly used equation for the second

<sup>9</sup> See Jorgenson; Robert M. Coen, "Investment Behavior, the Measurement of Depreciation, and Tax Policy," *American Economic Review*, Vol. 65, March 1975, pp. 61-73; Hendershott and Hu; Stephen L. Able, "Inflation Uncertainty, Investment Spending, and Fiscal Policy," *Economic Review*, Federal Reserve Bank of Kansas City, February 1980, pp. 3-13; and DeLeeuw.

<sup>10</sup> The time pattern of investment expenditures that follows a change in the optimal capital stock has been estimated

relationship relates the optimal capital stock to three variables: the level of output, the cost of owning an additional unit of capital, and the impact that an additional unit of capital will have on output. This relationship holds that the optimal capital stock rises if the level of output increases but declines as the cost of owning capital rises. It can be expressed by the following equation.

$$(2) K_t^* = \beta(Y_T/C_T),$$

where  $\beta$  = the percentage change in output for a 1 percent increase in the capital stock,

$Y_T$  = the level of output during time period T, and

$C_T$  = the cost of owning capital during time period T.

In the equation, the term  $\beta$  is commonly called the partial elasticity of capital in production and can be estimated with econometric techniques. The cost of owning capital, C, is not simply the price of capital goods; it also incorporates the impacts of changes in the cost of financing the investment, the economic life of capital, and corporate tax laws.<sup>11</sup>

many ways. Generally, the pattern turns out to be an inverted U, meaning there is very little investment immediately following a change in the optimal capital stock, but that investment then grows, peaks, and declines, becoming very small at some time in the future. An Almon lag, which constrains the coefficients on m past observations of the independent variables to lie on an n-th degree polynomial, was therefore used in estimating  $\theta(t)$ . Several different polynomials and lag periods were examined in this study, with a second degree polynomial covering eight quarters and tied at both tails being chosen as best.

See DeLeeuw; and Shirley Almon, "The Distributed Lag Between Capital Appropriations and Expenditures," *Econometrica*, Vol. 33, January 1965, pp. 178-96.

<sup>11</sup> This measure of ownership costs is commonly called the implicit rental cost of capital. Algebraically the implicit rental cost of capital can be stated as:

$$C = Pe/P \cdot \rho \cdot \left[ \frac{1}{1-F} \right] \cdot \left[ \frac{1 - t_c - t_\pi \cdot \left[ \frac{\delta}{\delta + \rho} \right]}{1 - t_\pi} \right]$$

where  $Pe/P$  is the real price of business equipment,  $\rho$  is the real user weighted average cost of capital, F is the dis-

The third relationship sums up the information in the other two equations and is derived by substituting equation (2) into equation (1):

$$(3) NI_T = \theta(t)(\beta(Y_T/C_T) - K_{t-1}).$$

According to the standard model of investment behavior, then, net investment during any time period depends on the level of output, the cost of owning capital during that period, and on the level of the capital stock at the beginning of that period.

### The Adjusted Model

One way to adjust the standard model for risk is to consider fluctuations in the cost of capital as adding to the level of these costs.<sup>12</sup> The standard model can then be adapted for the possibility that investors share an aversion to fluctuating profits by rewriting equation (2) as:

$$(4) K_t^* = \beta(Y_T/[C_T + \gamma(SDC_T)]),$$

where  $\gamma$  = the coefficient of the relative importance of risk versus profits, and

$SDC_T$  = the standard deviation (the square root of the variance) of the cost of capital.

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counted value of the wearout of one unit of capital (i.e.,

$F = \sum_{i=1}^{\infty} h_i(1 + \rho)^{-i}$  where  $h_i$  is the fraction of original capacity lost in each year),  $t_c$  is the investment tax credit rate,  $t_\pi$  is the corporate profit tax rate, and  $\delta$  is the fraction of the capital stock that can be depreciated for tax purposes in a year.

<sup>12</sup> Equation (4) was actually developed by assuming investors utility functions are related to both the level and standard deviations of profits. This type of tradeoff between the expected value and the risk (variation) of important arguments is normally called E-V analysis and has had substantial use in economic literature. Equation (4) is simply a restatement of one of the first order conditions for the utility maximization of the investor. The standard deviation of the implicit rental price enters the equation in a way that can be interpreted as increasing the cost of changing the level of the capital stock. Since the investor is assumed to be permanently increasing the level of the capital stock, variations in interest rates will be important since he will have to finance the future replacements of the investment that he is currently undertaking.

The tradeoff between risk and profits,  $\gamma$ , is positive if investors are averse to fluctuations in profits. Larger fluctuations in the cost of capital can then be viewed as an increase in the level of costs. Higher perceived costs lead in turn to a lower optimal capital stock and less investment.

Substituting this new definition of the optimal capital stock into equation (1), the following function can be obtained:

$$(5) NI_T = \theta(t)(\beta Y_T/[C_T + \gamma(SDC_T)] - K_{t-1}).$$

This equation can then be used to test for the effects on investment of the volatility in the long-term cost of capital.

### Empirical Results

Historical information on all of the variables was needed in order to use statistical techniques to estimate the coefficients. Constant dollar gross national product was used to measure output,  $Y$ . To calculate the cost of owning capital,  $C$ , the maximum corporate tax rate, legal minimum service lives of business equipment, the deflated price index for business equipment, the long-term interest rate, and business profits and assets were used.

The actual level of the capital stock,  $K$ , is difficult to measure. Part of the problem lies in identifying the proper depreciation pattern that should be used in developing a measure of the capital stock which is related to the services it provides. Such a pattern does not necessarily follow the same time pattern as either tax or book value depreciation. For these reasons, none of the published capital stock data could be used in this study. A new measure of the capital stock was therefore developed.<sup>13</sup>

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<sup>13</sup> A 12-year straight-line wearout pattern was used to

**Table 2**  
**RESULTS OF ESTIMATING THE STANDARD INVESTMENT MODEL**  
**AND THE RISK-ADJUSTED INVESTMENT MODEL**

(Sample Period: 1953:I-1981:II)

Dependent Variable: Real Net Investment in Business Equipment

Model	Intercept	$\beta$	$\theta$	$\gamma$	$R^2$
Standard	-1.0004* (0.3580)	0.0801* (0.0005)	0.0242* (0.0043)		0.6882
Risk Adjusted	-0.9946* (0.3672)	0.0775* (0.0040)	0.0260* (0.0044)	-1.0545† (0.6785)	0.6908

$\beta$  = partial elasticity of production.

$\theta$  = partial adjustment coefficient.

$\gamma$  = risk factor, the tradeoff between risk and profits.

\*These coefficient values are statistically significant.

†These coefficient values are not statistically significant.

Note: Standard errors are shown in parentheses.  $R^2$  is adjusted for degrees of freedom.

Table 2 reports on the results of estimating both the standard and the risk adjusted models. Both models were estimated using quarterly observations running from the first quarter of 1953 through the second quarter of 1981. The models were estimated using ordinary least squares and other econometric techniques. The estimates of both coefficients,  $\beta$  and  $\theta$ , in the standard investment model have reasonable signs and magnitudes and are statistically significant. The adjusted  $R^2$ , a measure of how well the model explains the historic data, of .69 is somewhat lower than found in many time series regressions. However, it is quite good for estimating residual net investment after removing the time trends introduced by inflation.<sup>14</sup>

depreciate gross investments reported in the National Income Accounts as investments in producers' durable equipment. See Coen, pp. 61-74, for arguments consistent with the capital stock of business equipment yielded by this pattern. Adjustments were also made to remove investment in pollution control equipment since they are required by law. See Hendershott and Hu for details on the construction of this time series.

<sup>14</sup> If the same sum of squared errors is used to calculate an  $R^2$  for real gross investment, the measure increases to 0.96.

The results of estimating the risk adjusted model do not support the hypothesis that the volatility in long-term rates is a significant deterrent to investment. While two coefficients,  $\beta$  and  $\theta$ , retain the proper signs and are still statistically significant, the coefficient of the risk factor,  $\gamma$ , is estimated to have the wrong sign and is statistically insignificant.

### THE VOLATILITY OF SHORT-TERM INTEREST RATES AND THE LEVEL OF LONG-TERM INTEREST RATES

This section tests the third assumption underlying the argument that the Federal Reserve's new focus on the growth of money and credit decreases investment. Some work in this area has already been done by Roley in fit-

This adjustment is appropriate since depreciation is a definition including only past investments and therefore has no error term. Other statistical tests (Chow tests) were performed to test the stability of the coefficients of the model but did not change the conclusions reached.

ting nominal interest rate yield curves.<sup>15</sup> He concluded that volatility in short-term interest rates has only a small impact on the average level of longer term rates. However, the same conclusions may not be true over a time period that includes observations after October 1979. Also, they may not hold for real interest rates. Thus, an effort was made to identify what effect, if any, variations in short-term real interest rates might have on the level of long-term interest rates.

A structural model of aggregate demand and supply is used to test the impact of short-term interest rate volatility on the level of long-term rates. The model includes equations explaining consumption, investment, total gross national product, the demand for money, and the supply of output. These equations are combined with a yield curve equation and an equation explaining inflationary expectations. The last two equations connect the short-term nominal interest rate that clears the financial markets to the long-term real interest rate used to determine investment in the goods markets. The model can be solved for a reduced-form equation that explains the long-term interest rate as a function of monetary and fiscal policy variables, past inflation, the inflationary gap (actual minus potential output), and the variation in short-term interest rates. The reduced-form equation is:

$$(6) \rho_T = a_0 + a_1 m_T + a_2 g_T + a_3 tr_T + a_4 \dot{P}_{T-1} + a_5 IG_T + a_6 \sigma_{rT},$$

where  $\rho_T$  = the long-term after-tax cost of capital,

$m_T$  = the real stock of the narrowly defined money supply, M1-B,

$g_T$  = the annualized rate of real government expenditures,

$tr_T$  = the effective personal income tax rate,

$P_{T-1}$  = past inflation rates,

$IG_T$  = the inflationary gap,

$\sigma_{rT}$  = a 12-month moving standard deviation of real after-tax short-term commercial paper interest rates, and,

$a$ 's = estimated coefficients developed so that several past values of the variables have an impact on the current level of  $\rho$ .

If when estimating this equation, the coefficient,  $a_6$ , of the volatility of interest rates,  $\sigma_{rT}$ , is greater than zero, there will be evidence that variations in real short-term interest rates tend to add to the cost of long-term financing. If  $a_6$  is less than or not significantly different from zero, then it will not be possible to conclude that variation in short-term real interest rates translates into higher long-term real rates.

The results of estimating this equation are shown in Table 3.<sup>16</sup> The adjusted  $R^2$  of .90 is high for studies which seek to explain real rates of interest. All coefficients other than  $a_6$  are of the expected signs. However, the coefficient on the variability of the short-term interest rate,  $a_6$ , is not statistically significant. Thus, there is insufficient evidence to conclude that the level of long-term cost of capital increases as short-term real interest rates become more variable.<sup>17</sup>

## SUMMARY AND CONCLUSIONS

This article has examined the argument that the Federal Reserve's concentration on controlling the growth of money and credit has

<sup>15</sup> See Vance Roley, "Interest Rate Variability, the Level of Interest Rates, and Monetary Policy," *Economic Review*, Federal Reserve Bank of Kansas City, September-October 1978, pp. 17-27.

<sup>16</sup> Many different lag structures were tried for the independent variables, using adjusted  $R^2$  to determine the best fit.

<sup>17</sup> See work done by Jim O'Brien reported in Johnson for further confirmation of this conclusion.

**Table 3**  
**RESULTS OF ESTIMATING THE REDUCED-FORM EQUATION**  
**FOR THE REAL AFTER-TAX LONG-TERM COST OF CAPITAL**

(Sample Period: 1953:1-1981:11)

Coefficient Estimates							
Intercept	m	g	tr	P	IG	$\sigma_r$	$R^2$
0.0583* (0.0129)	-0.0159* (0.0036)	0.0015* (0.0001)	-0.1772* (0.0535)	-0.0169 † (0.0172)	0.00008* (0.00001)	-0.0028 † (0.0851)	0.9032

m = the real money stock, M1-B.

g = annualized rate of real government expenditures.

tr = effective personal income tax rate.

P = past inflation rates.

IG = inflationary gap.

$\sigma_r$  = 12-month moving standard deviation of real short-term commercial paper interest rates.

\*These coefficient values are statistically significant.

†These coefficient values are not statistically significant.

Note: Standard errors are in parentheses. Regression has been corrected for serial correlation of the error terms.

decreased investment by making interest rates more volatile. Tests were made of the following three assumptions underlying this argument: first, that the volatilities of interest rates relevant to investment decisions rise as the Federal Reserve places greater emphasis on monetary control; second, that the increased volatilities of these relevant interest rates measurably reduce aggregate investment; and third, that the increased volatilities of short-term interest rates due to Federal Reserve actions increase the level of long-term interest rates relevant to investment decisions. Each of these points was tested against the evidence of past interest rates and investment decisions.

The results of testing the first assumption showed that short-term interest rates have become more variable in recent years. However, long-term rates have not shown the same increase in volatility. Nominal long-term interest rates fluctuated more in the post-1979 period than they did during the 1970s, but the

variance of these rates is much the same as it was during the 1950s and 1960s. The real after-tax cost of capital showed a decrease in volatility during the 1970s and only a minor increase since October 1979. Consequently, the linkage between variations in short-term interest rates and variations in the real cost of capital is weak, if not nonexistent. Thus, it is difficult to state that long-term rates of interest have become more volatile as a result of monetary policies allowing short-term rates to fluctuate.

The second and third assumptions held up little better under scrutiny than did the first. A test was performed on the second assumption to see if larger fluctuations in the cost of capital deter investment. No aggregate impact of variations in the rental cost of capital on investment was found. As to the third assumption, the level of the cost of owning capital was found to be important in explaining aggregate investment decisions. It followed that if it could be shown that volatility in short-term rates increased the

level of long-term rates, the Federal Reserve's policy of focusing on controlling the growth of money and credit could reduce the level of investment. However, when a full model of the economy was used to identify all of the relevant variables explaining the long-term cost of capital, variations in short-term rates were not found to be a significant variable.

In conclusion, data do not seem to support the argument tested in this article. None of the important components of the argument tying

the operating procedures of the Federal Reserve System to investment were confirmed by an analysis of what actually occurred in the economy. Higher interest rates, no doubt, have reduced investment. However, those who argue that additional reductions in investment can be attributable to the variability in interest rates associated with the current operating procedures of the Federal Reserve must find tests other than those used in this study to support their argument.

# Modeling Agriculture for Policy Analysis in the 1980s

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## MODELING AGRICULTURE FOR POLICY ANALYSIS IN THE 1980S



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Agricultural policy issues, in both the public and the private sectors, have become increasingly complex—and increasingly intertwined with other economic and political issues. In the years ahead, these issues will be of considerable importance and urgency to farmers and to nonfarmers alike. Yet the methodology used to support decisionmaking in these areas has not kept pace with the emerging issues.

A better understanding of econometric modeling and its distinctive agricultural applications will help identify these shortfalls in policy analysis methodology and will contribute to proposed solutions.

Agricultural issues of supply-demand balance, instability, structure, and resource limitations will be prominent in the 1980s. Econometric modeling is an indispensable component of agricultural policy analysis which can provide basic information to help resolve these issues.

In September 1981, the Federal Reserve Bank of Kansas City sponsored a two-day symposium on this important topic, proceedings of which are now available. Proceedings are also still available from previous years' symposiums, *World Agricultural Trade: The Potential for Growth*; *Western Water Resources: Coming Problems and the Policy Alternatives*; and *Future Sources of Loanable Funds for Agricultural Banks*.