Economic Review
Federal Reserve Bank of Cleveland

Quarter I 1985

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The rate of increase in fine paintings prices was large when compared with many other investments during the 1970s and was extraordinarily large from 1977 to 1980. One prominent explanation for the behavior of fine painting prices over this period is the ability of this asset to hedge against uncertain inflation. This article models the market. return for fine paintings from an investment perspective and investigates the influence of uncertain inflation 'on painting returns.

Recent changes in Federal Reserve operating procedures and reserve accounting rules have led to major changes in the market for bank reserves. Economists William T. Gavin and Nicholas V. Karamouzis describe changes made by the Federal Reserve over the last seven years. The authors show how market participants have used Information in the weekly M1 announcements to predict reserve market conditions under alternative rules and procedures. They also present evidence on the efficiency with which market participants forecast the weekly M1 data.

Economic Review is published quarterly by the Research Department of the Federal Reserve Bank of Cleveland, EO. Box 6387, Cleveland, OH 44101. Telephone: 216/579-2000.

Editor: William G. Murmann. Assistant editor: Meredith Holmes. Design: Jamie Feldman. Typesetting: Lucy Balazek.

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ISSN 00134281

Michael F. Bryan is an economist with the Federal Reserve Bank of Cleveland. *The author would like to acknowledge, without implicating, John Carlson, William Gavin, Laurence Kantor, and K.J. Kowalewski for their comments on an earlier draft of this article. The research assistance of Diane Mogren and Michael Pakko is greatly appreciated.*

1. The original application of this model to paintings prices was done by Stein (1977) for the period 1946-1968.

2. For a more thorough analysis of the influence of inflation on asset returns, see Kantor (1983).

Beauty and the Bulls: The Investment Characteristics of Paintings

by Michael F. Bryan

This article examines the investment and consumption characteristics of the paintings market between 1971 and 1984, using the capital asset pricing model.[1]

There are two principal motivations behind this research, Owners of paintings may be regarded both as consumers of aesthetics and as investors possessing a claim on future consumption. Since fine art prices increased in value by 11 percent per year on average between 1971 and 1984, and by 19 percent per year between 1977 and 1980, the investment character of the art market appears prominent and worth investigation.

Paintings and other "collectibles" belong to the durable goods class of commodities because they provide current consumption and claims on future consumption. In this sense, they differ little from automobiles or real estate. Insofar as durable goods yield a service flow to the owner over time, as opposed to the nominal income flow associated with financial assets, owners of durable assets are in some measure protected from unexpected inflation because the value of the service flow increases along with the general price level.

The nominal return on the durable asset, from the investment perspective, is inflation "hedged" in a way that returns from other investments (for example, stocks and bonds) are not?[2] The analysis of the paintings market in this paper may provide additional insights to the performance of other durable goods markets during periods of inflation.

I. Measuring Fine Art Prices: The Sotheby's Index

The market for fine art operates in a capricious environment. Over short periods of time, auctioned art prices are subject to extreme market fluctuations. Art is often sold in groups, or "collections." The composition of a collection can vary considerably from one auction to the next, in terms of object types

3. Another art market price index is constructed by Christie's Limited, also of London.

(paintings, ceramics, furniture, etc.), in period (Renaissance, Impressionist, Modern, etc.), in reputation of the artist, and in condition of the object.

Reputation of the seller, rumors, "taste" swings, and auction location (London, New York, Hong Kong, Monaco, etc.) can also temporarily influence individual auction activity, further contributing to short-term price instability.

From the perspective of the art consumer, distinguishing temporary price movements from underlying appreciation is generally important only as a curiosity.

The pleasure received from the object over its life relative to its discounted purchase price need only be greater than that of other goods. Indeed, the product turnover in the art market has historically been quite low, and many art collections are sold only following the death of the owner.

This suggests that, from a historical perspective, the art market has been dominated by the art lover and not by the investor. To the investor, however, the distinction between a temporary price fluctuation and asset appreciation in the marketplace is crucial. As investor interest in the art market intensified in the 1960s, financial analysts pressured art experts to measure underlying price appreciation in the fine art market. Like most price statistics, this information takes the form of an index.

One of the most popular art market price indexes is produced by Sotheby's auction house in London.[3] Essentially, the index does for fine art objects what the Consumer Price Index does for consumer goods and services.

The index represents a fixed basket of about 300 art objects categorized into 12 major components: Old Master paintings, Nineteenth Century European paintings, Impressionist and Post-Impressionist paintings, American paintings (1800 to pre-World War II), Modern paintings (1900–1950), English furniture, American furniture, Continental furniture, English silver, Continental silver, Chinese ceramics, and Continental ceramics.

A Sotheby's expert on each of the 12 components tracks auction prices. The expert then reappraises Sotheby's market basket objects on the basis of the recent price information. These valuation judgments, although highly subjective, attempt to filter out special or temporary influences from price data.

The major commodity components are weighted with respect to each component's share of combined sales by major New York and London auction houses during 1975, aggregated into a total art market index, and standardized at 1975 = 100.

For this analysis, an all-paintings index was constructed from four major paintings components in the Sotheby's index: Old Masters, Impressionist and Post-Impressionists, Nineteenth Century European paintings and drawings, and Modern Paintings (see appendix).

Table 1 Asset Return Correlations 1971–1984

	Paintings	Gold	Housing	Stocks	AAA bonds
Paintings	1.000				
Gold	0.666[a]	1.000			
Housing	0.321	0.477[b]	1.000		
Stocks	0.003	-0.213	0.204	1.000	
AAA bonds	0.336	0.243	0.307	-0.162	1.000

a. Significant at the 5 percent level of confidence.
b. Significant at the 10 percent level of confidence.

II. Recent Behavior of Paintings Appreciation

We begin by comparing the investment return on paintings with the return on alternative assets, including gold, housing, stocks, and bonds (table 1).

Over the period of analysis (1971–1984), inter-asset correlations reveal a strong positive relationship between the rate of increase in the price of paintings and in the price of gold. The only other significant correlation was found between housing and gold price changes.

Thai the rate of return in the market for paintings correlates more closely with the market return on gold than with returns on financial assets (which are high in investment characteristics relative to consumption characteristics) or with returns on housing (which offers much greater consumption returns relative to financial assets) implies a rather. mixed personality.

Our first impression of the art market, therefore, seems to be one of an asset that fits neatly neither into the world of consumers nor the world of investors.

Since the investor interest in the fine paintings 'market is at least partially a function of the rate of inflation, we can test the sensitivity of paintings prices to changes in the general price level and to real growth in the U.S. economy (see appendix for results). The elasticity of paintings prices, with respect to real economic growth and the general price level. was significantly positive over the test period. The sensitivity of paintings prices to the general price level was near, but less than unity (elasticity = 0.96). while the real economic growth elasticity was stronger (elasticity = 1.35).

Despite the statistical strength of the estimates, the presence of serial correlation gives us reason to suspect that this simplistic specification obscures the underlying investment nature of the paintings market.

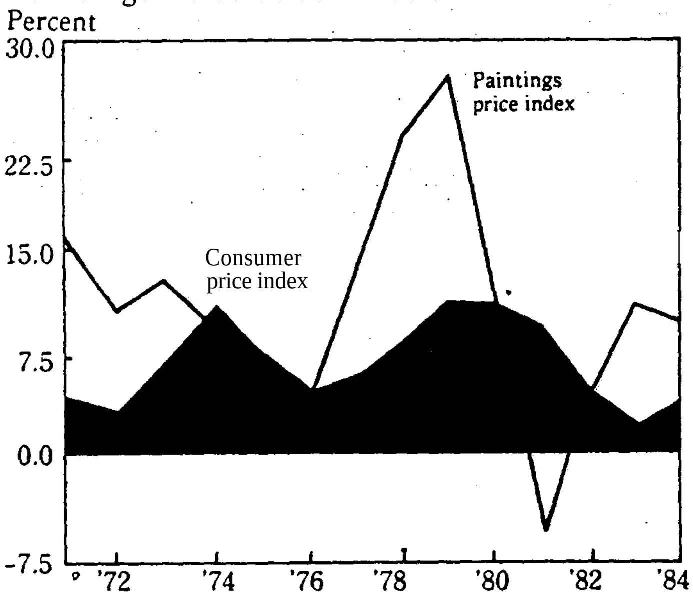
Figure 1 shows the behavior of the all-paintings index relative to the Consumer Price Index since 1970. Over the 15-year period, the rate of appreciation in paintings typically outpaced the rate of increase in the general price index. Howevei-, within short intervals (1973–1977 and 1980–1982), paintings price appreciation did not keep pace with inflation. During one year of inflationary pressure (1980–1981) paintings actually depreciated in value.

In short, while the rate of appreciation in paintings is positively related to the general price level, and moreover has outpaced inflation over the full period of analysis, its year-to-year performance has been considerably volatile.

In the language of the financial analyst, returns on paintings involve a degree of risk. One cursory measure of investment risk is the standard deviation of the investment return.

Table 2 compares the average annual rate of return and standard deviation in the paintings market between 1971 and 1984 against a sample of alternative investments. The rate of return in paintings was high over the sample period, relative to four major investment alternatives: gold, stocks, bonds, and housing. This contrasts with the finding of Anderson (1972) and Stein (1977) that demonstrated a rather weak return to paintings relative to other financial assets over earlier time horizons. Indeed, only investment in gold outperformed paintings over the sample period chosen here. The volatility of the art market return, however, also was above average, exceeded only by the volatility of gold and stock returns.

Fig. 1 The Rate of Return on Paintings Relative to Inflation



Within the paintings market basket, the investment return and volatility among major components was quite mixed. For example, Nineteenth Century European paintings fared much better during the period of analysis than Old Master paintings (average return of 15.5 percent vs. 8.7 percent), and the former appeared to be only somewhat more risky (standard deviation of 15.6 percent vs. 12.7 percent). Moreover, the return on Impressionist and Post-Impressionist paintings was 10.3 percent, despite a comparatively low return standard deviation of only 7.1 percent.

III. Capital Asset Pricing Model

The casual analysis above merely places fine paintings price increases in perspective. Standard deviation estimates of return volatility are not very adequate measures of investment return risk, because they lack any theoretical underpinning.

To characterize nominal asset return behavior more formally, it is necessary to formulate an economic model of returns. Because paintings have dual personalities—being at once investment goods and consumer goods—their price behavior can be modeled from the consumer perspective, adjusting for investment characteristics (Anderson 1982 and Singer 1974), or modeled from the investment perspective, adjusting for consumption characteristics (Stein 1977).

The primary interest in this analysis is the investment side of paintings; consequently, the modeling approach chosen here takes the investment perspective and uses the capital asset pricing model (CAPM) represented by equation (1).

$$(1) \quad (R^e_{a,t} - R_{f,t}) = \beta(R^e_{m,t} - R_{f,t}).$$

This time series application of a rather popular investment model, originally postulated by Black, Jensen, and Scholes (1972) and estimated by Stein (1977) for paintings prices over the period 1946–1968, relates the expected nominal one-year rate of return on the relevant asset in time period t ($R_{a,t}$) in excess of a risk-free rate of return ($R_{f,t}$) as a function of the expected rate of return on a market portfolio ($R_{m,t}$) in excess of a risk-free rate of return. The estimated coefficient, β, represents the paintings market risk relative to the market portfolio risk—called ***relative systematic risk.***

For example, β estimates greater than 1 imply the relevant asset has proportionately greater risk than the market portfolio, and estimates less than 1 imply proportionately less risk than the market portfolio.

One may further visualize the expected return on paintings ($R^e_{a,t}$) as having two components: the expected return in consumption (viewing pleasure), $R^e_{c,t}$, and the expected investment return ($R^e_{i,t}$). More formally:

$$(2) \quad R^e_{a,t} = R^e_{c,t} + R^e_{i,t}.$$

Table 2 Pre-Tax Returns and Standard Deviations of Alternative Household Investments, 1970–1984 (annual rates)

Investment	Rate of return	Standard deviation
Gold	16.2	31.4
Paintings index	10.7	8.2
Stocks	8.4	19.4
One-year Treasury bonds	7.9	2.3
Market portfolio	7.1	4.8
Inflation	7.0	3.1
Housing	6.4	4.3
AAA corporate bonds	6.1	2.5
19th century European paintings	15.5	15.6
Chinese ceramics	14.3	37.7
Modern paintings	11.9	11.8
All paintings	10.7	8.2
Impressionist paintings	10.3	7.1
English silver	9.1	13.7
Old Master paintings	8.7	12.7

If we assume that the rate of return on paintings from viewing pleasure is nearly constant over time, equation (2) can be combined with equation (1) and rewritten as:

$$(3)\quad (R^e_{i,t} - R_{f,t}) = \beta_0 + \beta_1(R^e_{m,t} - R_{f,t}).$$

The intuition behind equation (3) is the same as equation (1), except for the constant term. β_0, which represents any superior return (or systematic deviation) from what would be predicted by the asset's relative systematic risk, less the expected return in art viewing pleasure. R^e_c. For goods that yield no consumption services and that operate in an efficient market with no transactions costs or taxes, β_0, will be near zero.[4]

Unfortunately, this simple CAPM model is mis-specified under conditions of uncertain inflation where the inflation hedging characteristics of the asset in question deviates from that of the market basket.[5]

It can easily be shown that under conditions of price uncertainty, differences between the nominal rate of return of an asset and what was expected ($R_t - R^e_t$) are equal to the difference between that asset's real rate of return from what was expected ($r_t - r^e_t$) and errors in inflation expectations ($P_t - P^e_t$), or:

$$(4)\quad (R_t - R^e_t) = (r_t - r^e_t) + (P_t - P^e_t).$$

Notice that when nominal rates of return are fixed, errors in inflation expectations generate errors in expected real asset returns.[6] Alternatively, where assets are hedged against inflation — that is, where errors in inflation are incorporated completely into nominal asset premiums — the real rate of return for the asset is fixed.

To adjust for uncertain inflation in the CAPM, this study employs the specification:

$$(5)\quad R_t - R^e_t = b(P_t - P^e_t) + v_t,$$

where b represents the degree to which asset returns are hedged against inflation, and v_t is a normally distributed error term with a mean zero and a constant variance. A $b = 1$ implies that the real return on the asset is unaffected by inflation forecasting errors (that is. the asset is a perfect hedge against inflation). A $b = 0$ implies the rate of return on the asset is completely exposed to inflation forecasting errors. or the asset is "unhedged."

Combining equation (3) with (5) gives a CAPM under conditions of price uncertainty (CAPMUI) in the form of equation (6):

$$(6)\quad R_{i,t} - R_{f,t} = \beta_0 + \beta_1(R_{m,t} - R_{f,t}) + \beta_2(P_t - P^e_t) + \epsilon_t,$$

where

$$\beta_2 = b_i - (b_m)(\beta_1),$$

and

$$R_{i,t} - R^e_{i,t} = b_i(P_t - P^e_t),$$

$$R_{m,t} - R^e_{m,t} = b_m(P_t - P^e_t).$$

Using the actual consumer price performance over the year less expected consumer price increases, equation (6) was estimated annually over the 1971–1984 period.[7] The return on the market portfolio reflects a weighted average of the return from stocks, bonds, and real estate. The risk-free rate of return is represented by the one-year yield on U.S. Treasury securities held until maturity. A dummy variable was included to capture special influences that occurred in the art market, namely proposed changes in British taxation rules involving art and the U.S. legalization of private gold ownership, which jointly severely depressed fine art prices in 1975. The estimation results are reproduced in table 3.

Under this CAPMUI specification, paintings were found to be a moderately risky investment when compared against the yield on a diversified market portfolio (although not significantly so), since the relative systematic risk of paintings was found to be slightly greater than 1 ($\beta_1 = 1.15$).

Within the paintings market basket, individual painting periods generated different results. The return on Old Masters paint-

4. Stein (1977, p. 1,029) has argued earlier that any positive annualized premiums to account for the tax advantages of art and negative premiums to account for illiquidity should be small because of the relatively long holding period of paintings. Further, these two influences will tend to cancel one another.

5. See Lawler (1978). Since data on expected nominal return rates are unobserved. the standard CAPM is estimable using the assumption that expected rates of return deviate from actual rates of return by a random, normally distributed error with a mean ϵ_t of zero, or:

$$R^e_t = R_t + \epsilon_t.$$

During periods of uncertain inflation, when hedging characteristics vary across assets. this assumption is violated, as errors in expectations may not be random. For a good discussion of the standard assumptions used in deriving and applying the standard CAPM, see Niagorniak (1972).

6. See Kantor (1983, p. 28).

7. The expected inflation values were obtained from the University of Michigan's **Survey of Consumer Attitudes (1984).**

8. *Ideally, the market portfolio should include all assets available for private ownership. Because of weighting difficulties, some assets that may be considered components of household wealth, such as gold and farm land, were excluded from the market return calculations.*

9. *Other assumptions regarding b_m would yield different interpretations of the inflation-hedging strength of the paintings market. Some studies—Nelson (1976), Bodie (1976), and Jaffe and Mandelker (1976)—suggest that b_m may actually be negative. Although a negative b_m would imply a smaller value for b_i, even these extreme estimates were not large enough to reject the hypothesis that b_i = 1.00.*

10. *It must be noted that a significant intercept term may also reflect the influence of market factors, which are not adequately introduced into this simple specification.*

11. *Conversations with art curators tend to support this result. Investor interest in the art market may be relatively limited to moderately priced objects.*

ings was found to have a relatively large risk factor (β_1 = 1.34), compared against the more conservative return on Impressionist and Post-Impressionist paintings (β_1 = 0.97). Of all the components tested, Modern art registered the least systematic risk (β_1 = 0.92), while Nineteenth Century European drawings and paintings showed the greatest risk factor (β_1 = 1.54).

The price expectation error coefficients, β_2, give an indication of the impact of uncertain inflation on the asset. The inflation-hedging ability of paintings, relative to the market basket, depends on the sizes of b_i and b_m. Knowledge of β_1 and β_2 enables inferences about b_i and b_m to be drawn.

In all cases, the results strongly suggest that the inflation-hedging ability of paintings was superior to that of the market basket tested. However, the pure inflation-hedging ability of the asset (b_i) is not econometrically identified. If we assume that b_m = 0; that is, the total portfolio is unhedged against inflation, the point estimate of the inflation-hedging strength of the paintings market, b_i, is greater than 1 (b_i = 1.76). This result implies that paintings returns are completely hedged against uncertain inflation? The constant terms, which include any superior return over the 1971–1984 period, less the return in art viewing services, were all positive and generally significantly different than zero.

From this result, we can infer that over the period of analysis, the returns in the art market were lucrative for the pure art speculator.[10] The largest superior returns were found in the market for Nineteenth Century European drawings and paintings, with a nonsystematic return coefficient of 7.2 percent.

Of the individual art categories tested using this CAPMUI specification, the capital asset pricing model fit best for Modern paintings (R^2 = 0.80), an indication that this particular market most closely resembles a standard investment market over the sample period, while a market such as Nineteenth Century and Old Masters paintings was only weakly approximated by this investment behavior specification.''

It should be noted that as the art market becomes more disaggregated, the ability to model its behavior accurately becomes more difficult, because the actions of a small circle of investors can influence price patterns. For example, the rather dramatic volatility in Nineteenth Century paintings prices may, in part, be explained by a few investors driving up the prices of particular artists or even specific works and may not be an accurate appraisal of the market for other Nineteenth Century types.

Conversely, the conservative nature of the Impressionist and Post-Impressionist paintings market may reflect greater product homogeneity, which is to say that this market may have a relatively wide appeal. Consequently, individual buyers are probably less influential in the marketplace for Impressionist and Post-Impressionist paintings.

The results found in this analysis are largely consistent with the earlier studies, with one notable exception: fine paintings prices yielded superior returns for the pure art speculator.

Over the extended horizon of 1780 to 1970, the risk-adjusted return on paintings was estimated by Anderson (1972) to be superior only for the art lover. The art investment return over this 190-year period was only 50 percent of that earned on common stock. Stein, on whose original work this project is based, found that over the period 1946–1968 the investment return on paintings provided only about 73 percent of the return earned on common stock. In our current analysis, the rate of return on a paintings basket exceeded that earned by stocks by approximately 30 percent.

12. This analysis is done with apology to the art connoisseur, who may believe that the appreciation of fine art transcends economic valuation.

13. A check on art insurance costs uncovered a range of estimates, from a low of 0.14 percent of the object's appraised value to a high of almost 2 percent. For the individual investor with a total art value of over $1,000, insurance was generally under 0.5 percent of the object's appraised value per year.

IV. A Word on the Consumption Value of Art

An important issue, which is only implied in the CAPM model is the "value" that art provides in viewing pleasure." A check on the value of viewing services can be made through the rental art market, where the art consumer enjoys only the art, and the investment returns accrue to the owner.

Many museums have partially developed rental markets. A few have fully developed markets that lend objects of fine art to corporations, universities, public offices, and individuals. Unfortunately, the rental market is almost exclusively within the contemporary art market, to which this analysis may not directly apply.

Further, the cost of art rental is determined by many factors, such as whether the owner or the renter bears the cost of insurance.[13] Moreover, the renter frequently has the option to buy the object, which may distort the true rental return implied by the rents earned in these markets.

For these reasons, the actual rental price of the type of art found in the Sotheby's art basket is unknown. In 1977, Stein set the rental price of paintings at no more than 11 percent of the object's appraised value. More recent estimates of rental costs in the contemporary fine art market, which included the option to buy, ranged from 17.8 percent to 19.7 percent!.' Compared with the 11.9 percent investment return in the Modern paintings component of Sotheby's art index (its closest relative) it yielded an approximate service return in the contemporary art market of 6 percent to 8 percent a year between 1971 and 1984.

In one case, a corporate rental program for certain "traditional" Nineteenth and Twentieth Century art works, also with an option to purchase, found an average return of about 29 percent (a.r.). Compared with 'the 15.5 percent investment return by its closest coun-

Table 3 Capital Asset Pricing Model Regression Results, 1971-1934

$$(R_p - R_f) = \beta_0 + \beta_1(R_m - R_f) + \beta_2(P - P^e) + \beta_3 Dum75 + \epsilon$$

	β_0	β_1	β_2	β_3			
Paintings	0.041 (1.91)[b]	+1.15 (3.00)[a]	+1.76 (1.84)[b]	-0.17 (2.04)[b]	$R^2 = 0.56$	$DW = 1.40$	$F = 4.31$
Old Masters	0.028 (0.70)	+1.34 (1.89)[b]	+1.20 (0.67)	-0.20 (1.32)	$R^2 = 0.31$	$DW = 1.52$	$F = 1.45$
Impressionists	0.036 (2.27)'	+0.97 (3.38)"	+1.34 (1.87)[b]	-0.16 (2.50)[a]	$R^2 = 0.62$	$DW = 1.54$	$F = 5.48$
19th century	0.072 (1.46)	+1.53 (1.75)	+2.84 (1.30)	+0.04 (0.22)	$R^2 = 0.31$	$DW = 1.22$	$F = 1.51$
Modern	0.061 (3.10)[a]	+0.92 (2.64)[a]	+2.70 (3.11)[a]	-0.37 (4.87)[a]	$R^2 = 0.80$	$DW = 1.45$	$F = 13.02$

NOTE: All equations were estimated using ordinary least squares (t-statistics in parentheses).
a. Significant at 5 percent.
b. Significant at 10 percent.

Original Stein Regression (R_m = stock returns), 1946-1968

	β_0	β_1		
Paintings	-0.016 (-0.45)	+0.82 (2.30)	$R^2 = 0.24$	$DW = 2.18$

14. The contemporary art market was defined as art produced by living artists. and traditional art was defined as that product by artists no longer alive.

15. For corporate borrowers, the range of those exercising the buying option was between 25 and 33 percent, given a sample of five rental programs. The programs considered were the Philadelphia Museum of Art (Philadelphia, PA). Chicago Art Institute (Chicago. IL), Kansas City Art Museum (Kansas City, MO), the Newport Harbour Museum of Art, (Newport Harbour. CA), and the Fogg Art Museum (Cambridge. MA).

terpart in Sotheby's Art Index (Nineteenth Century European paintings), it yielded a traditional art service return of approximately 13 percent.[15]

Given these rental cost estimates, it appears safe to conclude that during the past 14 years. the art market was a superior investment for those who aiso enjoy the beauty of paintings.

V. Conclusion

This analysis is not intended to serve as a basis' for individual investment decisions. The actual investment performance of any art object depends on events that cannot be accurately reproduced by the simple financial model and short sample period presented here.

Even in the aggregatk. the CAPMUI equation for all paintings showed an R^2 of 0.56, which is to say that this specification only "explains" a little more than 50 percent of the variatidn in paintings prices over the 1971–1984 period.

However, the results of this analysis suggest that, on average, the total paintings index was not measurably more risky than a market portfolio Containing stocks, bonds, and real estate. Moreover, even for the pure art speculator, paintings were generally superior investments (that is, they generated returns in excess of comparable risk) over the test period when compared against the market portfolio proxy.

Of the individual art components studied here, Nineteenth Century drawings and paintings were found to have the greatest systematic risk, and Modern paintings were the most conservative performers. Most importantly, these results demonstrate that nominal paintings returns were relatively more inflation-hedged than the representative market. portfolio, especially Modern paintings.

The degree to which the paintings market is hedged against uncertain inflation is undefined in this model. Yet, if the market basket used here is a good approximation of the complete market portfolio, and if this portfolio's hedging ability is near zero, then these results suggest that paintings are virtually completely inflation-hedged.

Finally. given only limited information on returns in the rental art market, this analysis was also unable to determine conclusiveiy the magnitude of the consumption returns from art. However, we can conservatively guess that art lovers enjoyed very sizable returns from owning paintings due to the additional consumption service they provided.

Data Appendix

Annual rates of return were calculated on a third-quarter to third-quarter basis, because the Sotheby's index was computed only during September between 1967 and 1981. After 1981, the Sotheby's index is available monthly. Compounded rates of return were estimated by using natural logarithms.

The data used in this analysis were:

Bonds
AAA Corporate Yield from Moody's.

Stocks
The stock return estimates were approximated using price changes and dividends from 500 stocks as calculated by Standard and Poors.

Gold
Gold prices were found using the CPI retail price per troy ounce.

Housing
Housing prices were estimated using the CPI-W home purchase price component.

P
The rate of inflation estimate used in this study was the Consumer Price Index for all urban consumers (CPIU).

P^e
The price expectations data used in this analysis are average consumer price increase expectations over the next 12 months, obtained from the University of Michigan Institute for Social Research, Surveys of Consumer *Attitudes*, September 1984.

R_f
The risk-free rate of return is represented by the one-year rate of return on new-issue U.S. Treasury bonds held until maturity.

R_m
The return on the market portfolio was calculated using a weighted average of housing, bonds, and stock market returns. The weights applied came from the asset's share of outstanding household net worth normalized to 1.

R_t^a
The Sotheby's Index is available monthly in *Barron's*. For a complgte explanation of the construction of the index.. see "Unveiling Sotheby's Art Index," *Barron's*, November 4, 1981; and "The Sotheby's Index: What's In It?" Baryon's, February 15, 1982.

Elasticity estimates
The constant elasticity estimates for paintings prices (P_p) were estimated annually over the 1970–1984 period using the log-transformed regression:

$$\ln P_p = -9.85 + \underset{(4.19)}{0.96 \ln P} + \underset{(2.22)}{1.35 \ln \text{Real}\, GNP} + \underset{(1.70)}{0.30\, \text{RHO}}$$

$R^2 = 0.96$, DW = 1.58
(t-statistics in parentheses)

References

Anderson, Robert C. "Paintings as an Investment:' Economic Inquiry, vol. 12, no. 1 (March 1974). pp. 13–26.

Ang, James S.. Jess H. Chua, and Walter J. Reinhart. "Monetary Appreciation and Inflation-**Hedging** Characteristics of Comic Books:' The Financial Review. 1983. pp. 196–205.

Black, Fischer. Michael C. Jensen, and Myron Scholes. "The Capital Asset Pricing Model: Some Empirical Tests:' in Michael C. Jenson, ed.. *Studies in the Theory of* Capital *Markets*. New York: Praeger Publishers. 1972. pp. 79–121.

Bodie, Zvi. "Common Stocks as a Hedge Against Inflation," *The Journal of Finance*, vol. 31, no. 2 (May 1976), pp. 459–70.

Jaffe. Jeffrey F., and Gershon Mandelker. "The Fisher Effect for Risky Assets: An Empirical Investigation:' *The Journal of Finance*. vol. 31, no. 2 (May 1976), pp. 447–58.

Kantor, Laurence G. "Inflation Uncertainty and Inflation Hedging:' *Economic Review*. Federal Reserve Bank of Kansas City (September–October 1983), pp, 24–37.

Lawler, Thomas A. "Uncertain Inflation, Systematic Risk, and the Capital Asset Pricing Model:' Working Paper Series 78-2. Federal Reserve Bank of Richmond (February 1978), pp.1–5.

Nagorniak, John J. "The Application of the Capital Asset Pricing Model to Debt and Equity Markets:' in Giorgio F. Szego and Karl Shell, eds., *Mathematical Methods in Investment and Finance*. Amsterdam: North Holland Publishing Company, 1972. pp. 344–66.

Nelson, Charles R. "Inflation and Rates of Return on Common Stocks:' The *Journal* of Finance, vol. 31, no. 2 (May 1976), pp. 471–83.

Singer, Leslie. "Microeconomics of the Art Market," *Journal* of Cultural *Economics*, 1974, pp. 21–40.

Stein, John Picard. "The Monetary Appreciation of Paintings," *Journal of* Political *Economy*, vol. 85, no. 5 (1977), pp. 1,021–35.

University of Michigan, Survey Research Center. Surveys of Consumer Attitudes, Institute for Social Research, September 1984.

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The Reserve Market and the Information Content of M1 Announcements

By William T. Gavin and Nicholas V. Karamouzis

I. Introduction

In the last five years, there have been many changes in the institutional arrangements of monetary control. Understanding these arrangements is an important factor in gauging the short-term effects of monetary policy.

Participants in the money market monitor information about short-run changes in the tools of monetary policy, because correctly predicting Federal Reserve behavior is a major factor in correctly predicting changes in the cost of very short-term funds. People outside the money market monitor such information in an attempt to predict shifts in the longer-run stance of monetary policy.

This *Economic Review* article describes the changes that have taken place both in the process generating the federal funds rate and in the procedures used by the Federal Reserve to guide policy on a day-to-day basis. The authors show how institutional changes affect the market for bank reserves and explain how weekly money stock announcements have been used by reserve market participants to predict future events in the reserve market.

The authors conclude that the two most recent changes by the Federal Reserve—the switch to a borrowed reserve operating procedure in October 1982, and the switch to contemporaneous reserve accounting rules in February 1984—have led to reductions in the information about the reserve market that one can extract from money stock announcements.

The money stock announcements have become relatively unimportant for predicting events in the contemporaneous reserve market, both because the Federal Reserve is targeting borrowed reserves, which tends to smooth interest rates on a weekly or biweekly basis, and because much of the reserve-market information previously associated with the money stock announcement is now outdated. Under the new contemporaneous reserve requirements, the reserve market clears before the M1 data are released.

II. The Reserve Market

In this paper, we are concerned with the use of the information in the M1 announcement for predicting events in the reserve market. To keep the analysis simple, we use a partial equilibrium model of the reserve market. Contemporaneous activity in other markets is important for the reserve market, but the importance lies mainly in the future. The inability of the banking system to arbitrage reserves intertemporally (between reserve settlement periods) tends to isolate the reserve market so that the federal funds rate depends mainly on current or past money growth and on the supply of reserves provided by the Federal Reserve in any given reserve settlement period.

The federal funds rate is the interest rate in the market for inter-bank reserve loans. The demand for reserves is a function of banks' demand for funds to meet legal reserve requirements and demand for clearing balances. The supply of bank reserves comes from the Federal Reserve, either through open-market operations or lending through the discount window.

Throughout this paper, we assume that market forces operate to keep the federal funds rate equal to the rate that is expected on the final day of the reserve settlement period. Any change in the rate is the result of a change in expectations about reserve supply or reserve demand for the current reserve settlement period.

In order to explain the reaction of the federal funds rate to the money stock announcement. we have to look at three factors: the reserve accounting rules underlying demand for reserves, the operating procedures underlying supply of reserves, and the timing of the release of aggregate information about demand and supply.[1] (See appendix for detailed description of the change in reserve accounting rules.)

Reserve Demand

The demand for reserves is largely determined by the level of bank deposits and by the structure of reserve requirements against bank deposits. In the absence of reserve requirements, banks would still need reserves as clearing balances to hedge against the uncertainty associated with fluctuations in deposit and loan activity.[2] However, reserve ratios have been high enough in the past so that required reserves have been greater than reserves demanded for clearing purposes. As a result, the market has been able to reduce excess reserves to very low levels. The use of the carryover provision and active trading in federal funds has also helped reduce excess reserves associated with uncertain reserve flows on the last day of the reserve settlement period.[3]

Required reserves were calculated against deposit levels of two weeks earlier during the period of lagged reserve requirements (LRR) from September 1968 to February 1984. Thus. under LRR, the demand schedule was very inelastic with respect to interest rates, because reserves were calculated against predetermined levels of deposits. Changes in interest rates could not affect the past deposit levels. This inelasticity is illustrated by the steepness of the demand curves in figure 1. Under the current form of contempbraneous reserve requirements (CRR), required reserves are predetermined on the last two days of the reserve settlement period. Therefore, we have not made a distinction between LRR and CRR in figure 1.

Reserve Supply

The shape and location of the reserve supply schedule are determined by the Federal Reserve's operating targets and procedures.

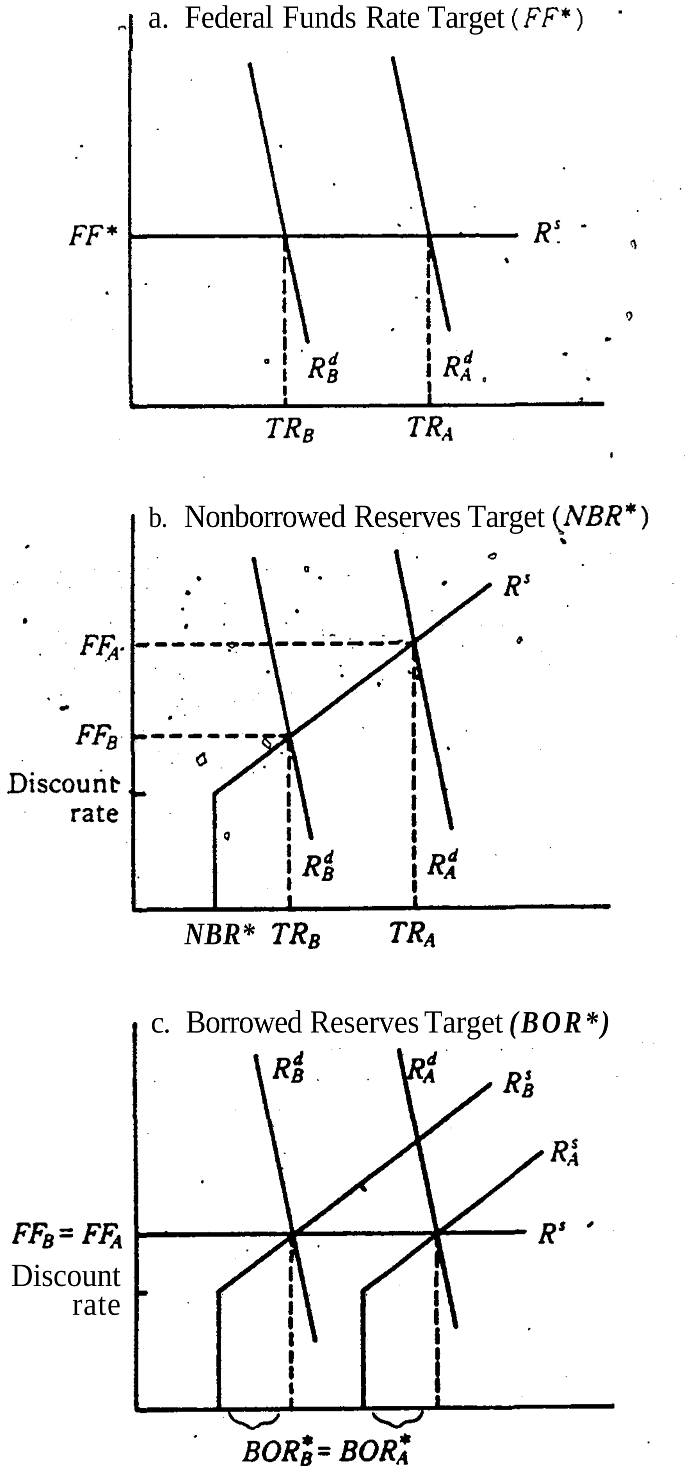
1. See Tinsley, von zur Muehlen, and Fries (1982); McCallum and Hoehn (1983); and Walsh (1982) for the derivation of analytical expressions showing the unplanned change in the federal funds rate expected under different operating procedures and different reserve accounting regimes.

2. See Niehans (1978), Chapter 9, for a theoretical analysis of the demand for bank reserves. The term bank is used to include all depository institutions.

3. See Friedman and Roberts (1983) for a discussion of the cartyover provision. This clear and concise discussion explains why excess reserves might appear to be perfectly inelastic with respect to interest rates.

In the planning stage, this policy can be characterized by the intended growth rate for M1 over a suitable time horizon. For this study, we consider that horizon to be the two- or three-month interval for which the Federal Reserve Open Market Committee (FOMC) set short-run paths for M1.

Fig. 1 The Reserve Market



The same planned growth rate for M1 can be achieved using very different operating procedures. The operating procedure can be defined by an instrument and a feedback rule. The Federal Reserve's instruments include the discount rate and one of the following: the federal funds rate, the level of nonborrowed reserves, or the level of borrowed reserves. In general, we define the instrument as the variable that is chosen by the FOMC and maintained by the Federal Reserve staff at the "same level until new instructions are received from the FOMC. Feedback is defined as the discretionary adjustments to the instrument made by the FOMC.

The form of the operating procedure is important because some operating procedures may be more effective than others in achieving a smaller discrepancy between planned and actual M1 growth. Since the monetary targets are merely intermediate targets, one cannot necessarily conclude that the optimal operating procedure is the one that gives the smallest discrepancy between planned and actual M1 growth in the short run.

Feedback can be used with any of the instruments to control M1 over a longer horizon. The major reason the operating procedure is important is that the form of the procedure (including the administrative procedures used at the discount window) determines the slope of the short-run reserve supply curve. This slope, in turn, determines whether shocks to the reserve market are absorbed by changes in interest. rates or by changes in reserves. A relatively elastic (flat) supply curve implies that shocks will be met by changes in the quantity of reserves. A relatively inelastic (steep) supply curve implies that shocks will be met by changes in the interest rate.

4. *Our period of analysis begins in September 1977 with the availability of survey data on expectations of the M1 announcement. Some may argue that the Federal Reserve began to operate more flexibly under the nonborrowed reserve procedure as early as July 1982. We chose October: because the decision was made to set aside the M1 target at the October FOMC meeting.*

5. *See Lombra and Moran (1980) for a detailed description of the policy process under the federal funds rate procedure. Also, see Wallich and Keir (1979) for a general discussion of interest-rate smoothing under the federal funds operating procedure.*

Whether a given shock should or should not be accommodated depends, in part, on the long-run objectives of the Federal Reserve and the nature of the shock. If the Federal Reserve is attempting to maintain a stable price level, then real shocks, such as fluctuations in investment or government spending, should be met by changes in the nominal interest rate. Financial shocks, such as fluctuations in money demand, should be absorbed by changes in reserves.

The most common of these financial shocks, the seasonal fluctuations in money demand, arise because of the regular weekly, monthly, and quarterly variations that arise from institutional details such as the average length of the payment period in the labor market, differences in cash management practices between households and firms, tax payment dates, holidays, etc. The seasonal adjustment procedure may be thought of as an attempt to supply reserves in a way that fully accommodates these transitory shocks to money demand. However, the errors in the estimated seasonal factors are quite large. Therefore, one reason to have an elastic short-run reserve supply schedule is to accommodate these hard-to-predict seasonal fluctuations in money demand.

The reason not to accommodate short-run shocks to the reserve market is to prevent accelerating inflation from becoming embedded in the economy, as it did during the inflationary period of the 1960s and 1970s, when the Federal Reserve did maintain a flat short-run reserve supply curve., In principle, the Federal Reserve could make discretionary shifts in a very flat short-run reserve supply curve and maintain long-run price stablity. In practice, this procedure has led to a great deal of uncertainty about future inflation.

In order to eliminate this uncertainty, central banks have adopted formal rules (such as monetary growth targets, exchange rate pegs, a commodity standard, etc.) that instill confidence in their behavior over the long run.

Given a long-run anchor for price stability, one can use the framework developed by Poole (1970) to show that an optimal short-run procedure would partially accommodate shocks of unknown origin, allowing both the federal funds rate and the quantity of reserves to adjust.

The period of our analysis includes three different operating procedures. Each of those procedures is described in detail below. We begin in 1977 with the federal funds procedure that was replaced in October 1979 by the nonborrowed reserve procedure. This procedure was replaced by the borrowed reserve procedure in October 1982.[4]

The Federal Funds Rate procedure

Following each regular meeting, the FOMC sent an operational directive to the manager of the open market desk at the New York Federal Reserve' Bank (hereafter referred to as the trading desk). The directive included short-run paths for M1 and M2 and a narrow range for the federal funds rate. The thrust of the policy intention under this, or any other, procedure can be described by the planned growth path for the monetary aggregates.

The FOMC used econometric and judgmental models of money demand to estimate the relationship between the monetary paths and the level of the federal funds rate. If the FOMC had been mechanically trying to achieve the monetary paths, it would have manipulated the federal funds rate target in response to new information about the money demand relationship. However, the FOMC did not mechanically react in this way. While changes in the federal funds target were made in the direction implied by mechanical application of the procedure, the changes were smaller than required to effectively control monetary growth. The FOMC showed a preference for smoothing changes in the federal funds rate?

A typical directive for this period included a federal funds range 25 to 50 basis points wide. Growth within the range was usually conditioned on growth of the monetary aggregates relative to two month paths that were chosen at the meeting. The range in the last week of September 1977 was 6 percent to 6.5 percent. The target was raised 16 times in the next 2 years, usually in response to monetary growth above the short-run provisional paths. The average change was 33 basis points so that the federal funds range was 11.25 percent to 11.75 percent in the last week before the change to the nonborrowed reserve operating procedure.

To comply with the directive, the trading desk would sell securities (thus draining reserves) whenever the federal funds rate was expected to trade consistently below the lower limit and buy securities (thus supplying reserves) whenever the federal funds rate was expected to trade consistently above the upper limit. Market participants used the level of the federal funds rate at the time of trading desk market intervention to estimate the limits on the operating range for the federal funds rate.

While the narrow federal funds rate range was subject to a proviso about short-run growth in M1 and M2, changes in the limits for the federal funds rate range were small (25 to 50 basis points) and infrequent (on average less than once a month). As a result of this procedure, the market not only knew the current target, but also could forecast the federal funds rate several weeks in advance with relatively small errors.

While market participants were well-informed about the location of the reserve supply function, they had little information about aggregate reserve demand. Individual banks could observe their own reserve requirements because requirements were calculated against deposits of two weeks earlier. However, market participants had little information with which to estimate aggregate reserve demand until the aggregate monetary data were released. Thus, while the weekly money stock announcement was important in predicting aggregate reserve demand, it was useful in predicting the reserve supply function only in so far as the federal funds rate limits were expected to be changed in response to a deviation of the money stock from the desired path.

The reserve market under the federal funds rate operating procedure is shown in panel a of figure 1. The reserve supply function R_B^s represents the end-of-period position of the reserve supply curve expected by market participants before the money stock announcement. The reserve supply function is infinitely elastic, representing the expectation that the Federal Reserve would maintain the federal funds rate in the target range, thus accommodating all short-run changes in the demand for reserves.

Likewise, R_B^d represents the reserve demand function expected by market participants before the money stock announcement. The reserve demand curve is inelastic with respect to the money stock and the federal funds rate because of LRR. The perceived federal funds rate target before the announcement is illustrated in panel a of figure 1 by a point estimate, FF*. This is the rate that is expected to prevail through the end of the reserve maintenance period.

Suppose that a large unexpected increase in M1 was announced. The expected end-of-period reserve demand curve would shift to the right. Because the public expected the Federal Reserve to accommodate unexpected shifts in the short-run demand for reserves, the cost of obtaining reserves through the end of the settlement period was expected to be relatively unchanged. We have portrayed the short-run reserve supply curve as perfectly horizontal on the assumption that there was no feedback to the change in M1 by the Federal Reserve. If there were a systematic revision of the target between the announcement and the end of the reserve settlement period, then the reserve supply function would have a positive slope. The feedback procedure used by the Federal Reserve to adjust the interest-rate target determined the information content of the unexpected part of the M1 announcement for the contemporaneous reserve market.[6]

6. However, we might expect medium- and long-term interest rates to rise if the market participants expect this increase in supply to intensify inflation, or if they expect the Federal Reserve to raise the interest-rate operating range in future weeks. See Cornell (1983) and Hardouvelis (1984) for an examination of the information content of money stock announcements in other markets and for a survey of the literature. Gavin and Karamouzis (1984) extend the evidence to include the experience under the borrowed reserve operating procedure and CRR.

7. *Goodfriend (1983) develops an aggregate borrowing demand function from a theory of the banking firm. He shows that the expected spread between the federal funds rate and discount rate is a non-linear function of past and expected future borrowing. This provides a channel for the expected future federal funds rate to influence the contemporaneous federal funds rate.*

8. *See Stevens (1981) for a detailed description of policy during the first two years of the nonborrowed reserve targeting procedure. See McCallum (1985) for further discussion of this point.*

The Nonborrowed Reserve Procedure

When the FOMC announced a change in operating procedure on October 6, 1979. there was a dramatic change in the information flow to the market about the relative position of the reserve supply functions for the period between FOMC meetings. The Federal Reserve constructed paths for reserves based on the short-run path for desired growth in the monetary aggregates. This procedure was made quite complicated by lagged reserve requirements. Since the level of required reserves was based on past M1, the FOMC was essentially forced to supply reserves to accommodate past M1 growth. However, it could affect future money growth by changing the price banks paid for reserves.

At the planning stage, this is the same analytical framework used in policy decisions before October 6, 1979. However, there were important differences. First, there was a change in the public discussion surrounding FOMC decisions. When the FOMC was choosing an explicit target for the federal funds rate, many observers attributed changes in the general level of all market interest rates to Federal Reserve policy. While the Federal Reserve could not control market interest rates, there may have been a perceived political constraint preventing large, discretionary changes in the federal funds rate target.

Second, and perhaps more important, neither the FOMC, nor anyone else, could predict the short-run changes in the interest rate that were necessary to achieve the Federal Reserve's monetary targets. By choosing a nonborrowed reserve target, the Federal Reserve allowed the market a greater hand in determining the level of the federal funds rate.

In the planning stage, the decision about the expected federal funds rate was made implicitly by the FOMC through the decision on the mix of nonborrowed versus borrowed reserves. Given the discount rate and total reserve demand (based on past money growth). the federal funds rate was positively related to changes in the ratio of borrowed to total reserves. The initial level of total reserves was calculated using the short-run monetary paths and estimates of the components of the money multiplier.

Using its money demand framework, the Federal Reserve staff estimated a federal funds rate that was consistent with the monetary path. Suppose this rate was FF_B shown in panel b of figure 1. The FOMC also used econometric and judgmental models to estimate the borrowing function. This is the upward-sloping portion of the reserve supply curve (R^s in panel b). Because Federal Reserve administrative guidelines discouraged banks from borrowing at the discount window, a greater spread between the federal funds rate and the discount rate was required to induce banks to borrow more at the discount window?

In theory, the intersection of the horizontal line through FF_B with the borrowing portion of the reserve supply function suggested an appropriate initial borrowing assumption. The target for nonborrewed reserves (NBR^*) could be calculated by subtracting this borrowing assumption from expected total reserves. In practice, the FOMC often chose the most recent level of borrowing as the initial borrowing assumption.[8]

In summary, under the nonborrowed reserve procedure, targets for nonborrowed reserves were based on a short-run target path for M1 and an initial borrowing assumption. The procedure was to maintain that path for nonborrowed reserves and to allow unexpected changes in money and total reserve demand to spill over into the discount window. The nonborrowed reserve path was adjusted by the Federal Reserve staff in response to currently known, but previously unexpected, changes in the multiplier. There was a proviso during this period stated as a wide band for the federal funds rate. Initially set to be four percentage points wide, it was at times as large as six percentage points.

Also, the FOMC sometimes chose to deviate from the short-run M1 path for other policy reasons. This could be done by changing the discount rate, which would lead to a vertical shift in the borrowing function. It could also be done by changing the nonborrowed reserve target which would lead to a horizontal shift in the reserve supply function.

Market participants calculated the expected nonborrowed reserve targets (NBR*) using information about the annual monetary targets, minutes from past FOMC meetings, and the latest information about M1. An unexpectedly large change in the weekly money announcement induced a corresponding shift in the expected aggregate-reserve demand curve, causing market participants to revise their expectations about the cost of federal funds.

Market participants scrambled for reserves immediately after the announcement of an unexpectedly large increase in the money stock, causing upward pressure on the federal funds rate. In panel b of figure 1, a surprise increase in the demand for reserves, from R_B^d to R_A^d would cause the federal funds rate to rise from FF_B to FF_A.

An important aspect of the nonborrowed reserve operating procedure was the automaticity in the response of interest rates to a deviation of M1 from the short-run policy path. Under this procedure, deviations of M2 and M3 were automatically accommodated by the weekly multiplier adjustments to the nonborrowed reserve path. For the short run at least, M1 was clearly the primary target.

In the second half of 1982, the FOMC decided that it did not wish to automatically react to deviations of M1 from the policy path, making the nonborrowed reserve procedure inappropriate. This decision was based on the uncertainty surrounding financial innovations, changing regulations, and the unusual behavior of M1 velocity.

The Borrowed Reserve Procedure

In October 1982, the FOMC set aside the M1 target and the nonborrowed reserve procedure. The directive to the trading desk called for a *degree of restraint* in the provision of reserves, often phrased in relative terms, such as *somewhat less*, *the same*, or *somewhat more* restraint. The FOMC made this directive operational for the trading desk by translating the degree of restraint into a target for borrowed reserves. The trading desk set nonborrowed reserve paths for one week at a time based on staff projections of reserve demand and on the borrowed reserve target chosen by the FOMC. On a day-to-day basis, therefore, nonborrowed reserves continued to be the instrument.

Under LRR, the Federal Reserve had good information about reserve demand. Each week (usually on Friday) the trading desk adjusted the nonborrowed reserve path to accommodate the shift in reserve demand. The procedure is portrayed in panel c of figure 1. The announcement of an unexpectedly large increase in M1 and in reserve demand was accompanied by a compensating dollar-for-dollar shift in the nonborrowed reserve path so that the borrowing target was maintained.

On a weekly average basis, this procedure looked much like the federal funds operating procedure in effect before October 1979. The nonborrowed reserve paths were adjusted each week to accommodate changes in reserve demand. Within the week, variations in the reserve market were along a given supply schedule.

From one week to the next, the supply schedule was shifted to match the expected change in reserve demand and, thus, maintain a given level for borrowed reserves. This borrowed reserve procedure was similar to the federal funds procedure on an interweek basis, as it led to expectations of a horizontal supply curve for total reserves from one week to the next.

One difference was that any shift in the borrowing demand curve after October 1982 led to a different federal funds rate. Another difference was in the daily operating procedure.

During the federal funds rate targeting period, the trading desk entered the market whenever the federal funds rate deviated from the operating target. During both the nonborrowed reserve and the borrowed reserve procedures, the Federal Reserve entered the market, if at all, only once a day, usually between 11:30 a.m. and noon. The operation was primarily defensive; that is, it was a response to offset movements in the uncontrollable sources of reserve supply, such as float, the Treasury balance at the Federal Reserve, and other factors. Also, the FOMC continued to set a proviso in terms of a wide band for the federal funds rate as it had done during the nonborrowed reserve procedure.

Market participants did not know the exact amount of the borrowing target. Neither they nor the Federal Reserve knew the exact location of the borrowing function. Consequently, market participants could not narrow down a small range for the federal funds rate as they had done prior to October 1979. The weekly averages were very stable, but since the trigger for trading desk intervention was primarily reserve quantities rather than the federal funds rate, the daily noise in the rate made it more difficult for the market to perceive changes in the stance of policy than had been the case when the federal funds rate was the operating target. Nevertheless, on an interweekly basis, the borrowing target could be described as an interest-rate smoothing procedure.

Due to lagged reserve accounting, the money stock announcement still contained information about the aggregate demand for reserves. However, under a borrowed reserve procedure, as under a federal funds procedure, the slope of the expected reserve supply function depends on the feedback procedure used by the Federal Reserve to adjust the borrowed reserve target. In panel c of figure 1, we have portrayed the case where there is no feedback. However, in this case, expectations of higher interest rates in coming weeks may cause an upward shift in the borrowing demand function, and the reserve supply would have a positive slope.

Contemporaneous Reserve Requirements

Finally, the recent change to contemporaneous reserve settlement rules has important implications for the effect of money stock announcements on the federal funds rate. Before February 2, 1984, the deviation of the money stock announcement from the expected level gave the market two types of information: the first was information about the aggregate quantity of reserves that would be demanded between the day of the announcement and the next Wednesday; the second was information about the position of the money stock relative to the perceived policy target.

Under CRR, the money stock announcements no longer include new information about aggregate reserve demand. The reserve data are released with a one day lag at the end of each two week reserve settlement period. The M1 data are released with a 10 day lag. The reserve market will have cleared before the money stock data for both weeks of the reserve settlement period have been released.

While the M1 announcement may contain new information about the level of M1 relative to the perceived policy target, the market now has better information than it had before the change in rules. To some extent, the level of M1 will be inferred from the information in aggregate reserves. Before CRR, the levels of deposits and required reserves against deposits were reported in the same week. Under CRR, the reserve data are available to be used in conjunction with multiplier projections to forecast M1. Whether this would be a useful procedure depends on the quality of the multiplier projections.

Furthermore, banks have installed new information-gathering systems to meet reserve

9. *We thank Mark Porter and Money Market Services for generously providing the survey data.*

10. *Hafer (1984) shows that the market does not try to predict seasonal and benchmark revisions of M1. Therefore, we have excluded those weeks from this study.*

requirements on a contemporaneous basis. Individual banks are learning more quickly about their own deposit levels, and they are pooling this information to make forecasts of M1. These factors suggest market expectations of M1 should have become more accurate after February 2, 1984.

III. Empirical Results

The objective in this section is to summarize empirical findings about how the pattern of federal funds rate response to unexpected money stock announcements has been influenced by the Federal Reserve's operating procedures and reserve accounting rules. We also look at the quality of the M1 forecasts.

The Data

M1 is the figure first published by the Federal Reserve in the H.6 press release. The expected change in M1 is calculated using the median of a survey taken by Money Market Services?[9] The expected changes (MMSP) are in billions of dollars. The expected change in M1 is calculated as:

$$EM_t = \log(M1_{t-1} + MMSP_t) - \log(M1_{t-1}),$$

where t refers to the week of the announcement rather than the statement week for which M1 was calculated. The unexpected change in M1 is calculated as:

$$UM_t = \log(M1_t) - \log(M1_{t-1} + MMSP_t).$$

The actual change in M1 is calculated as:

$$AM_t = \log(M1_t) - \log(M1_{t-1}).$$

We have used first-published numbers rather than revised numbers in making these calculations. This amounts to treating the revision as an unexpected change. Weeks that included seasonal or benchmark revisions were omitted from the sample.[10]

We used the M1 series that was published in the H.6 release. When the definition of M1 changed. our measure changed. Overlapping data were used to splice the series in early 1980. when the Federal Reserve changed the definition of M1 to include other checkable deposits.

The change in the federal funds rate (DFF) is calculated from the trade-weighted averages published in the H.15 release. Since the H.6 release (money announcement) was made available to the public on various days of the week throughout the sample period, we collected daily data on the federal funds rate. A "before-announcement" rate was taken as the last available value before the announcement. The "after-announcement" rate was taken as the first available value after the announcement. DFF, measured in basis points, is calculated as the difference between these rates.

Figure 2 depicts the time series for DFE The stochastic process generating the change in the federal funds rate subsequent to the announcement of a money stock surprise has apparently undergone change over this sample period. Changes in the response of the federal funds rate following money stock announcements are much larger during the nonborrowed reserve subperiod than in the rest of the sample period.

Casual inspection reveals another change between July and October of 1982. The variation in the series fell in the summer, but a systematic persistence or regularity is not evident until after October 1982. Variation in DFF has been reduced since the summer of 1982, but not to the low levels seen before October 1979. While the process generating DFF shows apparent change with changes in the operating procedures, there is no apparent change in the process generating the interest rate series with the switch to CRR.

The variance of *UM* (the median survey forecast error) was higher during the nonborrowed reserve operating procedure than it was during the other periods. There was also a tendency for the variance of the forecast

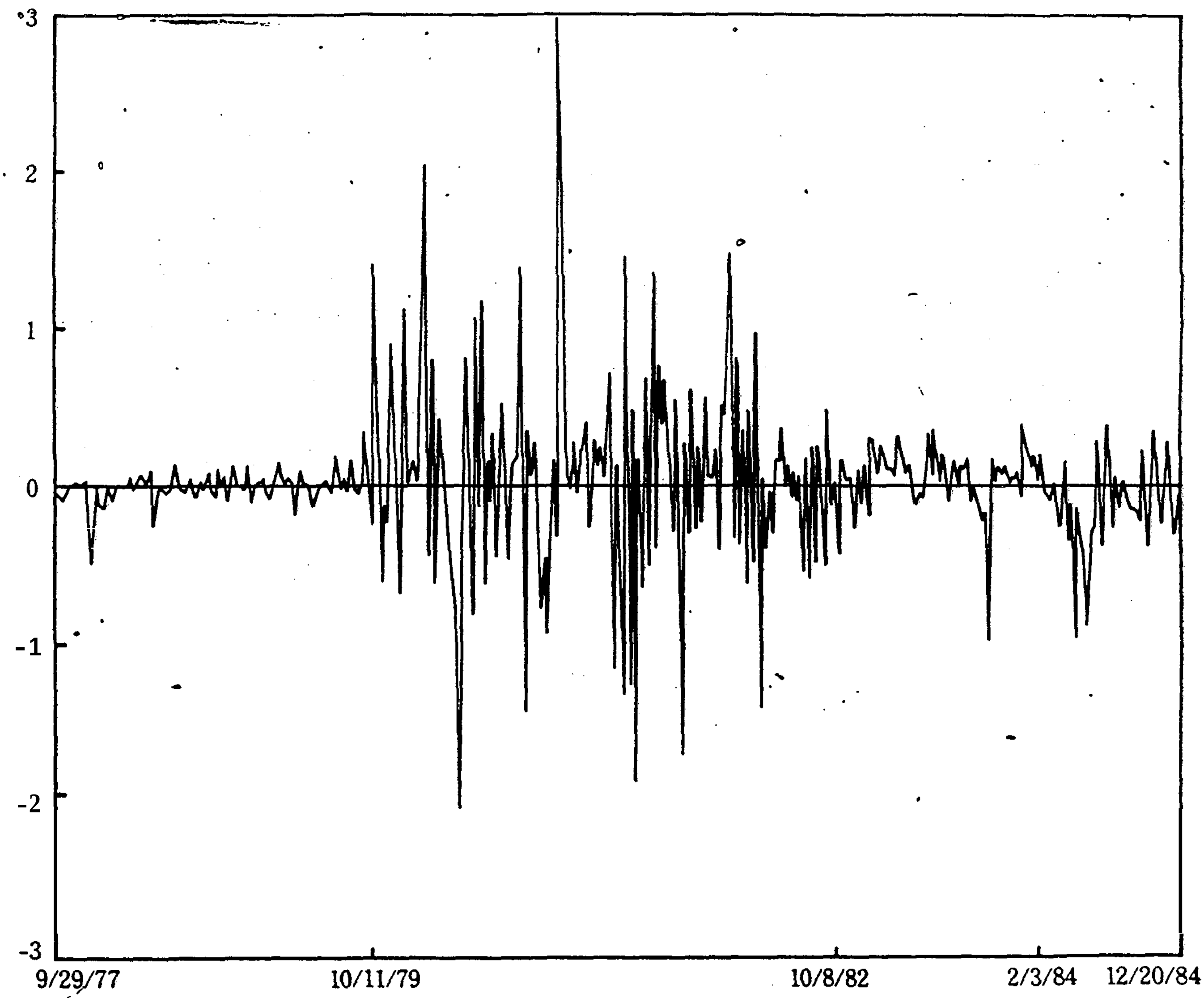
11. See, for example, Grossman (1981), Hafer (1983), Roley (1983), and Urich and Wachtel (1984). A forecast is defined as rational if the mean forecast is equal to the actual mean (it is unbiased), and if the error is not systematically related to past information (it is efficient).

error to fall. over time, after October 1979. This can be seen in table 1. which includes statistics measuring the accuracy of the M1 forecast.

We have regressed the change in the logarithm of first announced changes in M1 on a constant and on the median survey forecast. The constant was estimated to be different from zero in the period of federal funds rate targeting and in the last period under CRR. The coefficient on the expected change was not significantly different from 1, except in the last period. The explanatory power of the equation was lowest during the period of nonborrowed reserve targeting. It rose from 51 percent under the borrowed reserves targeting procedure and LRR to 75 percent with the switch to CRR.

Many authors have presented evidence on the rationality of the median of the survey forecast." In general, they find that the median survey forecast is unbiased and efficient, except during the early part of the nonborrowed reserve operating procedure.'

Fig. 2 The Change in the Federal Funds Rate Following a Money Stock Announcement



Hafer (1983) finds that median survey forecast errors are correlated with past information during this period. He attributes this apparent inefficiency to a learning process associated with the new procedure.

We have also found that the median survey forecast errors are correlated with past interest rates and actual M1 changes during this period. In a regression of *UM* on past announced changes in ME and past weekly changes in the federal funds rate, we cannot reject the hypothesis that 13-week lags in both variables help significantly in predicting *UM*. Webb (1984) points out that these in-sample tests are inadequate tests of rationality. As Webb predicts, we find that using the estimated systematic variation from the first half of the nonborrowed reserve period does not help predict M1 in the second half of the period. These results are available upon request from the authors.

We find a more serious problem with the forecast in the last period. While the forecast is unbiased in the first three subperiods, we cannot reject the hypothesis that it has been badly biased since the introduction of CRR (see table 1). Once again, the market may be going through a learning period. We saw above that the standard error of the forecast fell with the introduction of CRR. In table 1, we see that the explanatory power of the equation is highest in the last period even though the forecast is biased. There are two cases in which this estimated bias would not be a sign of irrationality.

The first is the case in which past estimated bias does not help predict M1 in the future. We followed the procedure suggested by Webb (1984) to construct a more powerful test of the rationality of the survey forecast in this period. We estimated the equation shown in table 2 over the first 31 weeks of CRR (deleting the February 16, 1984, observation due to seasonal and benchmark revisions) and used the estimated equation, $AM_t = -0.113 + 1.36\,EM_t$ to forecast the remaining 16 weeks of the sample period. The root mean squared error (RMSE) of the adjusted forecast was 22 percent lower than the RMSE of the median survey forecast, suggesting that the median

Table 1 Accuracy of the Median Survey Forecast

$$AM_t = c_0 + c_1 EM_t + e_t$$

Sample period	c_0	c_1	*SEE*	$\bar{R}^2$	DW
9/29/77 to 10/4/79 (103 observations)	–0.13 (–2.64)	1.16 (9.91)	0.42	0.49	1.81
10/11/79 to 10/1/82 (150 observations)	0.05 (1.06)	1.14 (8.12)	0.54	0.30	1.85
10/8/82 to 1/27/84 (68 observations)	0.05 (1.04)	1.13 (8.44)	0.37	0.51	2.23
2/3/84 to 12/20/84 (46 observations)	–0.14 (–3.07)	1.48 (11.69)	0.28	0.75	2.30

NOTE: The expected change in M1 is calculated as:

$$EM_t = \log(M1_{t-1} + MMSP_t) - \log(M1_{t-1}),$$

where *MMSP* is the median survey forecast of the M1 change, and *t* refers to the week of the announcement rather than the statement week for which M1 was calculated. The actual change in M1 is calculated as:

$$AM_t = \log(M1_t) - \log(M1_{t-1}).$$

SEE is the standard error of the regression, $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom, and *DW* is the Durbin-Watson statistic. We have excluded observations in which the announced level of M1 included an expected benchmark or seasonal factor revision. The t-statistics are shown in parentheses.

12. See Govin and Karamouzis (1984) for evidence that prior knowledge of the unexpected change in M1 would not have helped predict asset prices in the first months under CRR.

survey (*MMSP*) was not a rational forecast of the actual M1 change during this short period.

The second is the case in which predicting M1 more accurately does not help predict changes in asset prices more accurately. In this case the market may have little incentive to correct the systematic bias in predictions of M1.[12]

The Model

The empirical model used to examine the behavior of the federal funds rate following a money stock announcement is based on the efficient market hypothesis, which implies that the current asset price will reflect all publicly available information. Therefore, subsequent changes in the asset price should reflect only new information coming into the market. The empirical model takes the following form:

$$(1) \quad DFF_t = a_0 + a_1 UM_t + a_2 EM_t + e_t,$$

where

DFF_t = change in the federal funds rate from before the announcement to after the announcement.

UM_t = unexpected change in the money stock announcement at time t,

EM_t = expected change in the money stock at time t, and

e = error term.

Under the efficient market hypothesis, if expectations are rational, then a_0 and a_2 will be zero, and the error term will be random. If the money stock is an important factor in determining the federal funds rate, a_1 will be significant. In other words, under the efficient market hypothesis, only the unanticipated component of the M1 announcement should influence DFF because the federal funds rate level before the announcement should already reflect all relevant publicly available information.

The sample period, September 15, 1977, to

Table 2 Impact of Money Stock Announcements on the Federal Funds Rate

	Lagged reserve accounting			Contemporaneous reserve accounting
	Federal funds targeting	Nonborrowed reserve targeting	Borrowed reserve targeting	Borrowed reserve targeting
Estimation period	9/29/77 to 10/4/79	10/11/79 to 10/1/82	10/8/82 to 1/27/84	2/3/84 to 12/20/84
Constant	0.009 (0.79)	0.064 (1.17)	0.047 (1.77)	-0.070 (-1.14)
Surprise in M1	0.020 (0.92)	0.408 (4.11)	0.098 (1.49)	0.210 (1.64)
Expected change in M1	-0.023 (-0.89)	-0.161 (-0.94)	-0.035 (-0.49)	-0.337 (-2.76)
Autocorrelation coefficient	—	—	—	0.342
Standard error of the regression	0.092	0.651	0.203	0.265
Durbin-Watson	1.891	2.235	1.733	2.040
$\bar{R}^2$	-0.005	0.093	0.005	0.114
F statistics	0.724	8.645	1.161	3.907

NOTE: The t-statistics are shown in parentheses.

December 20. 1984, is divided into the four subperiods that correspond to different operating procedures or different reserve accounting regimes. The first subperiod began with the availability of survey data about expected, changes in M1 and covers the pre-October 1979 period of federal funds rate targeting. In this period, we do not expect the federal funds rate to respond to unexpected changes in M1.

The second subperiod covers the October 11, 1979, to October 1, 1982, period of nonborrowed reserve targeting and lagged reserve accounting. In this period, we expect a strong positive correlation between unexpected changes in M1 and subsequent changes in the federal funds rate.

The third subperiod covers the October 8, 1982, to January 27, 1984, period of borrowed reserve targeting and lagged reserve accounting. Since the trading desk is expected to fully accommodate unexpected shifts in reserve demand. we do not expect the federal funds rate to respond to unexpected changes in M1 under the borrowed reserve targeting procedure.

The last subperiod, February 3, 1984, to December 20, 1984, is a period of borrowed reserve targeting and contemporaneous reserve accounting. Since a borrowed reserve operating procedure is in effect, estimates of a_1 are expected to be insignificant unless there is a systematic shift in the borrowing demand function following a money stock announcement.

Reaction to Surprises in M1

The results from estimating equation 3 for lour different subperiods are reported in table 2. The coefficient of the unexpected change in the M1, a_1, is positive in all cases, but statistically significant at the 5 percent level only in the nonborrowed reserve targeting period. A 1 percent surprise in the money stock in that period resulted in a 40-basis-point increase in the federal funds rate. No statistically significant relationship was uncovered in the other three subperiods. These empirical results are consistent with the simple illustrations of the reserve market shown in figure 1. They indicate that the money stock announcement was not a significant factor in the current reserve market except during the period of nonborrowed reserve targeting.

Tests for Structural Change

We have assumed that either a change in the operating procedure or in the reserve accounting rules would cause a change in our estimates of the coefficients in the efficient market model. We calculated the Wald Statistic to test whether or not the estimated coefficients are equal for any two adjacent subperiods (see table 3). The hypothesis that the estimated coefficient vectors are equal is rejected at a 1 percent level of significance when the estimates from the federal funds targeting period are compared to the estimates from the nonborrowed reserve targeting period. The same hypothesis is also rejected at the 1 percent level of significance when estimates from the borrowed reserve targeting period under lagged reserve requirements are compared to estimates from the borrowed reserve targeting period under contemporaneous reserve requirements. However. we can only weakly reject (at a 10 percent level) the hypothesis that the vector of coefficients from the nonborrowed reserve period is equal to the vector of coefficients estimated for the period of borrowed reserve targeting.

The hypothesis that the estimated a_1 coefficients are equal is rejected at a 1 percent level of significance when the estimate from the federal funds targeting period as compared to the estimate from the nonborrowed reserve targeting period. This hypothesis is also rejected at a 1 percent level of significance when the estimate from the nonborrowed reserve targeting period is compared to the estimate from the borrowed reserve targeting period.

The same hypothesis cannot be rejected when the borrowed reserve targeting period under lagged reserve requirements is compared to borrowed reserve targeting period under contemporaneous reserve requirements. While the overall model changed with the introduction of CRR, there was no significant reaction to M1 in either period.

The Efficient Market Hypothesis

In no case is the constant term statistically significant. In addition, the estimates of a_2, the coefficient of the expected changes in M1, are not statistically different from zero in the first three subperiods. However, in the last subperiod of contemporaneous reserve accounting, the coefficient has a negative sign and the null hypothesis is not rejected at the 5 percent level. This finding, in conjunction with the presence of serial correlation in the residuals, raises concern about the efficiency of the market and/or the rationality of the forecast. We saw above that the median survey forecast was biased in this last period.

Roley (1983) finds a similar problem in the Treasury bill market during the period of nonborrowed reserve targeting. He constructed a revised expectation series by allowing for bias in the forecast, and by modifying the median of the Tuesday survey to include the new information (the change in the interest rate) from the time of the Survey to just before the money announcement. Using this revised forecast, Roley finds that the estimated coefficient of the revised expected change in M1 is not statistically different from zero.

Hein (1985) shows that if one does not correct for bias in the forecast, then the estimated coefficient of the revised expected change in M1 in Roley's model is again significant at the 5 percent level. We have found similar results for the federal funds rate under CRR. However, even when we constructed a revised forecast as in Roley, we could not eliminate the significance of a_2 or the serial correlation in the residual of the DFF equation.

Table 3 Large Sample Tests for Structural Change

	Wald Statistic for the null hypothesis	
	Vector a equal across periods	a_1 equal across periods
Periods compared	$\chi^2_{(3)}$	$\chi^2_{(1)}$
Federal funds targeting vs. Nonborrowed reserve targeting	16.25[a]	14.57[a]
Nonborrowed reserve targeting vs. Borrowed reserve targeting (LRR)	7.17[b]	6.77'
Borrowed reserve targeting (LRR) vs. Borrowed reserve targeting (CRR)	12.10'	0.61

NOTE: These tests are based on the Wald Statistic (W):

$$W = (\beta_1 - \beta_2)'[\sigma_1^2(X_1'X_1)^{-1} + \sigma_2^2(X_2'X_2)^{-1}](\beta_1 - \beta_2),$$

where β_i is the vector of regression coefficients and $\sigma_i^2(X_i'X_i)^{-1}$ is the variance-covariance matrix of the coefficients in the ith period. Unlike the Chow F test. this test does not require equal sample size or equal covariance matrixes across regimes. Watt (1979) presents Monte Carlo evidence to show that. in the presence of heteroskedasticity, this test is at least as powerful as the Jayatissa (1977) modification of the Chow test when the sample size is as large as 50. See Silvey (1975. pp. 115–116) for a description of the Wald Statistic.

a. Reject the hypothesis that the estimated coefficients are the same for the two sample periods with a critical region of 1 percent.

b. Reject the hypothesis that the estimated coefficients are the same for the two sample periods with a critical region of 10 percent.

IV. Conclusions

The role and formation of expectations have received considerable attention in the last decade. Studies have emphasized the importance of the market's perception of and reaction to new information about economic policy. This article examines the effect that monetary control arrangements have on the information content of the money stock announce-

a. This description of CRR applies only to banks that report deposits and reserves weekly and not to the small, quarterly reporters that are still subject to lagged reserve requirements and one week maintenance periods.

ments in the market for reserves. Specifically, we show that there was very little information in the announcement for the reserve market except during the period when the Federal Reserve used a nonborrowed reserve operating procedure, We show that the present operating procedure may be characterized as an interest-rate smoothing procedure.

Since the introduction of contemporaneous reserve requirements, we show that, while the error in the M1 forecast has been reduced, the forecast has been biased and the stochastic process generating the federal funds rate has not been consistent with statistical assumptions of the efficient market model. While we have rejected the statistical implications of the efficient market model for this short Sample period, we have not. rejected the economic implications; that is, we have not Shown that one could profit by using our model to trade in the reserve market.

Appendix: Contemporaneous Reserve Requirements and the Timing of the Weekly M1 Announcement

Between September 1968 and February 1984, banks were required to hold reserves against deposits on a lagged basis; that is, average daily reserves held in any given week were used to meet reserve requirements calculated from deposit levels of two weeks earlier. This lag was instituted in 1968 to give individual banks precise knowledge about the level of their reserve requirements. The lag also gave the Federal Reserve time to collect information about aggregate reserve demand.

In February 1984, the Federal Reserve implemented a return to almost contemporaneous reserve requirements (CRR)? The banking system had objected to this switch on the grounds that it would be costly to set up the information systems necessary to monitor deposit levels on an instantaneous basis. As a concession to this issue, the Federal Reserve chose a form of CRR that was not truly contemporaneous. Instead, the lag was reduced from 14 days to 2 days.

The new rules included other changes. One change is a lengthening of the reserve accounting period from one week to two weeks. Banks now post reserves, averaged over two weeks ending on a Wednesday, against deposits averaged over two weeks ending on a Monday, giving them two days to collect data on transactions deposits and to adjust their reserve positions accordingly.

Another change is that the lag on reserve requirements against other reservable deposits (nonpersonal time deposits and Eurocurrency liabilities) has increased from 14 days to 30 days. For example, reserve requirements held in a two week period ending Wednesday, March 13, 1985, were held against transaction deposits held in the two week period ending Monday, March 11, and against other reservable deposits held in the two week period ending Monday, February 11. Vault cash eligible to be counted as reserves in the period February 28 to March 13 was equal to vault cash held during the period January 29 to February 11—also a 30-day difference.

Under lagged reserve requirement rules (LRR), banks had been permitted to carry forward any excess or deficiency up to 2 percent of their required reserves. Any carryover not offset during the next period could not be carried forward into additional periods. There was a temporary change under the new rules. The new rules stated that the percentage of required reserves that an institution may carry forward would be 3 percent until August 1, 1984, and 2.5 percent until January 30, 1985. Thereafter, the percentage would be 2 percent or $25,000, whichever was greater. Since the 2 percent is based on reserves cumulated, not daily averages, the absolute amount of carryover is now double the amount allowed under LRR, because the reserve settlement period has been increased to two weeks.

There was also a change in the timing of the weekly money stock announcement. The announcement was moved up one day to Thursday, 4:30 Eastern standard time. Even though the Federal Reserve required banks to speed up the collection and reporting of deposit data, the actual data released on Thursday are slightly "older" than data that had been released on Friday. Under the LRR regime, the weekly money stock data released on Friday referred to the average daily level of M1 for the week ending on Wednesday, nine days earlier. Under the new arrangement, the data released on Thursday refer to the average daily level of M1 for the week ending Monday, 10 days earlier.

On the last day (Wednesday) of the reserve maintenance period, all banks have to meet their reserve requirements. This is an unusual market; we can think of no other where all firms are required to adjust inventories' to specified levels at the same time. During the reserve accounting period, before the money stock announcement, each bank can monitor its own deposits to estimate its individual reserve requirement, but it has no information about aggregate reserve demand. Under lagged reserve accounting rules, the announcement of M1 was made nine days after the end of the deposit computation period, but five days before the end of the reserve maintenance period. Consequently, the money stock announcement contained information about the aggregate demand for reserves in the settlement period that would end five days hence (see figure 3, panel a). Under CRR, the weekly announcements on Thursday apply to only half of a deposit computation period. The announcement of M1 for the first half of the deposit computation period is made one day after the reserve market clears. The announcement of M1 for the second half of the deposit computation period is made eight days after the reserve market clears (see figure 3, panel b).

Fig. 3 The Timing of Reserve Requirements and M1 Announcements