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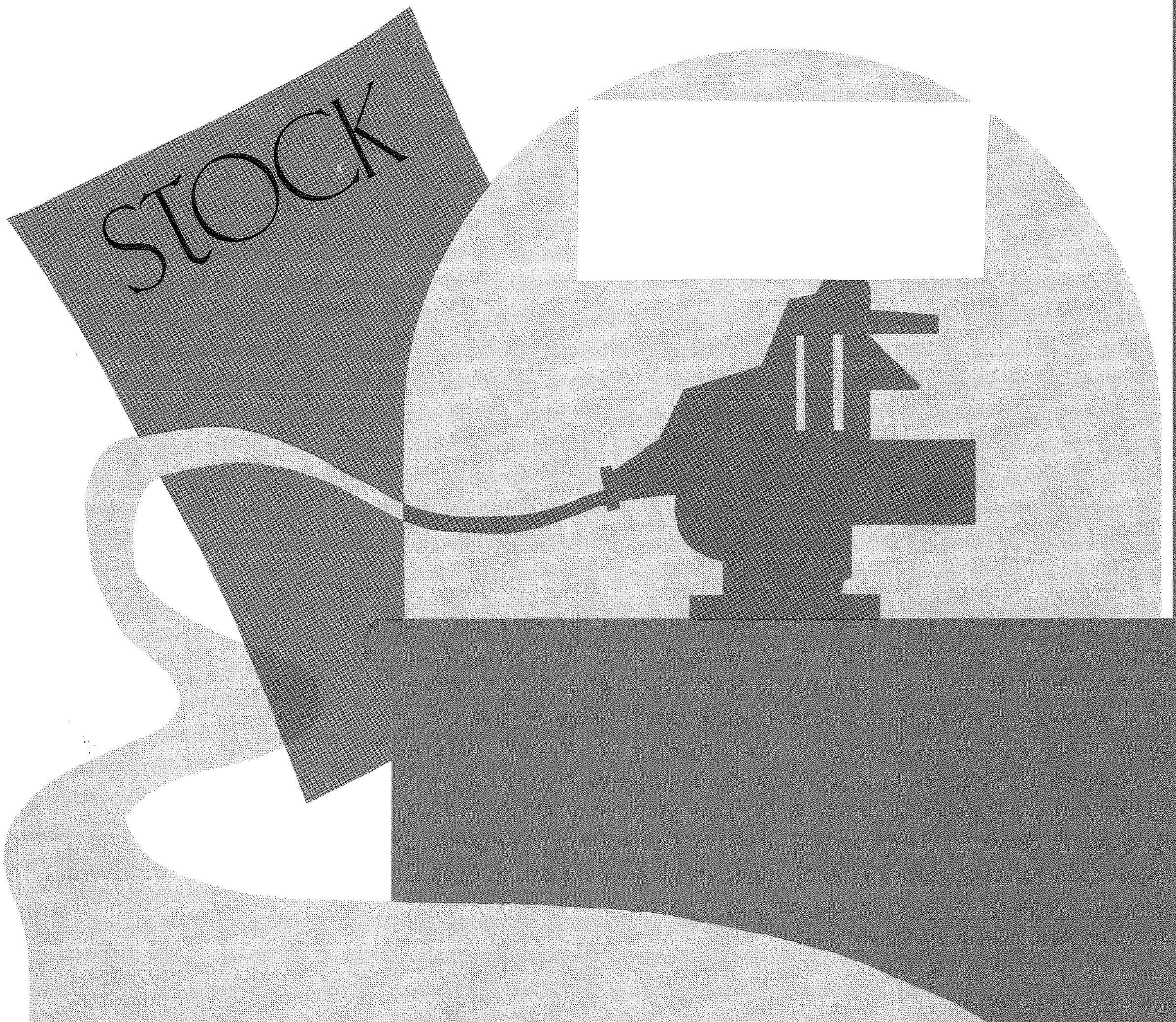

INFORMATION AND MARKET EFFICIENCY

SPRING 1978

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Markets provide consumers and producers with information—the prices at which they can buy and sell—which they need to make rational economic decisions. Economists judge market performance both by the reliability of the information conveyed and by the efficiency with which market participants utilize that information. The four articles in this issue examine questions of the quality of information and the efficiency of its use in various specific markets — Treasury bills, GNMA futures, commodity markets and the stock market.

William Poole applies such an analysis to the market for Treasury-bill futures which began trading in early 1976. The evidence suggests that the T-bill futures market is closely linked to the spot market in bills, at least for the nearest futures maturity. Unexploited arbitrage opportunities between the two markets rarely exist.

In Poole's view, the existence of the explicit interest-rate forecasts provided by the futures market emphasizes the need for policymakers to understand why discrepancies arise between market forecasts and their own interest-rate forecasts. "If, at some point in time, rates in the bill futures market are based on forecasts of a strong and/or more inflationary economy than projected by policymakers, and if the market is correct, then there is a danger that policymakers will determine a more expansionary policy than is appropriate for the needs of the economy."

Market interest-rate forecasts also may reflect forecasts of policies that are different from those that policymakers are actually planning. Consequently, policymakers should make their plans known and ensure that announced policy plans are realized. However, this raises the question of how adjustments may be made in response to changing economic conditions. Poole sees no easy solution to this dilemma, except perhaps by including in the concept of a policy plan an understanding of the policy adjustments required by certain contingencies.

Poole notes that today's futures rate is not an especially accurate forecast of "tomorrow's" spot rate, so that its policy significance ought not to be exaggerated. However, policymakers' own forecasts of interest rates are not very accurate either. "Unless policymakers have solid evidence that their own forecasts are more accurate than market forecasts, they cannot afford to ignore the T-bill futures market."

Kenneth Froewiss analyzes another new type of market — the futures market in the financial instruments of the Government National Mortgage Association (GNMA). This market was inaugurated in late 1975 by the Chicago Board of Trade, but it is the result of several earlier developments dating back to the late 1960's. The first was the mortgage industry's attempt to devise a hedging mechanism to protect itself from unforeseen interest-rate fluctuations. The second was GNMA's introduction of a new security — the pass-through certificate — to attract more investors to the housing market.

Froewiss' empirical results suggest that the GNMA spot market has improved its performance in the period since futures trading began in those securities. "The spot market has become more efficient in processing new information; it has shown less purely random price variability; and it has become more closely integrated with the rest of the bond market." Futures trading is not necessarily responsible for any of those beneficial developments, but it clearly has not had a destabilizing effect on spot-market prices of GNMA certificates.

Froewiss argues that these conclusions have a wider reference than to the GNMA market alone. Financial futures markets are still in their infancy, so that more and more of them are likely to be established. "The results of this study of GNMA futures suggest that we have nothing to fear and potentially much to gain from the further development of these markets."

Michael Gorham, in a third paper, discusses the development of information in commodity markets. Most market participants rely upon some source or sources of information to enhance their decision-making abilities, obtaining this information from both the public and private sectors. Gorham explores the relationship between public- and private-market information, with particular emphasis on a specific market with a large component of public-sector information — the market for agricultural commodities.

Gorham shows how public information both destroys and creates opportunities for providers of private-sector information. He then measures the private sector's response to these new opportunities in the case of three major agricultural commodities with highly-developed spot and futures markets. His analysis indicates that private-information sources correctly forecast public-sector announcements for soybeans, but not for corn and wheat.

For technical reasons, the quality of both types of information generally improves during each individual crop year. However, over longer periods, public-sector information has improved in quality, whereas the private sector's forecasting ability has lagged behind. Gorham does not find this surprising. "The public sector, unlike the private sector, is not constrained by considerations of profitability when adopting improved methods of forecasting or expanding its survey activities — although of course it is subject to certain budget constraints." The U.S. Department of Agriculture thus has been better situated than the private sector to improve its forecasting ability.

Kurt Dew, in a final paper, considers the information provided by the stock market as a means of analyzing changes in monetary-policy behavior. He poses the question — "Are changes in policy procedures only differences in style or does monetary policy now affect the economy in a substantially different way than it did in the 1960's?" Utilizing the theory of efficient markets, he answers by saying that the Federal Reserve's response to money growth *has* changed, and as a result, the economic impact of a temporary deviation of money growth from trend has actually been reversed.

Dew makes the case that the Fed today raises interest rates in response to undesirably rapid money growth, whereas it did not do so in the 1960's. This change in response is revealed indirectly, through an analysis of the stock market's response to the money supply. He points to evidence that the stock market today (unlike the 1960's) responds negatively to an increase in the money supply. He then bolsters his conclusion with the proposition that the stock market is an efficient forecaster of the future economic impact of a change in the money supply, which impact in turn depends on the Federal Reserve's policy reaction.

Dew argues that the new emphasis on the monetary aggregates has in fact altered the structure of the economy, and that most econometric models of the monetary-transmission process are misspecified as a result. He questions the naive interpretation of the portfolio-adjustment theory — namely, that an excess demand or supply of money precedes changes in long-term interest rates and equity values, which changes in turn influence levels of real economic activity. Dew's empirical work instead indicates that stock prices and interest rates primarily reflect anticipated trend rates of money growth. "Thus, according to a more accurate interpretation of portfolio theory, past rates of money growth affect current real economic activity only if they affect forecasts of future money growth."

Using T-Bill Futures to Gauge Interest-Rate Expectations

William Poole*

Trading in three-month Treasury-bill futures began on January 6, 1976. Six contracts were traded originally: March, June, September, and December of 1976, and March and June of 1977. When each contract matured, trading began in a new contract dated three months beyond the most distant contract previously traded. More recently trading has been conducted in eight contracts.

The details of this market and its uses in various types of hedging, speculative, and tax-motivated transactions have been fully described elsewhere.[1] The purpose of this paper is to provide an analysis of the link between the futures market and the spot market in Treasury bills of varying maturities, and to examine the policy significance of the interest-rate expectations incorporated in the T-bill futures.

In the first section of the paper, it is shown that the spot and futures Treasury bill markets are closely linked in practice; profitable arbitrage opportunities between the two markets rarely exist, at least for the nearest futures maturity traded at any given point in time. (Only this maturity is examined in this paper.)

In the second section the issue of liquidity, or term, premiums is examined. Studies of the term structure of interest rates have generally found that longer-term securities on average have higher yields than shorter-term securities. This finding is of importance in its own right, but it also implies that a term premium must be subtracted from a futures rate if that rate is to be interpreted as the market expectation of the future spot rate at the maturity of the futures contract. This rather technical issue is treated at some length, because it is of great importance in assessing the significance of yields in the futures market.

From evidence presented in previous studies of the term structure, and from new evidence on the futures market, it is argued that part of the observed term premiums may reflect transactions costs rather than risk aversion. The conclusion reached is that, since transaction costs in the futures market are almost non-existent, it is probably not necessary to make any allowance for term premiums when using futures rates to gauge market expectations of future spot rates.

In the last section, the policy implications of market interest-rate forecasts are explored. The major issue concerns the significance of differences between market forecasts and policymakers' forecasts of interest rates.

I. Relationships Between Spot and Futures T-Bill Markets

At the present time, eight contracts are traded in the Treasury-bill futures market. In August, 1977, for example, trading was conducted in futures for September and December, 1977; March, June, September and December of 1978; and March and June of 1979. Government security futures other than bills are also available. When yields on these securities get out of line with yields in the futures market, profitable risk-free arbitrage transactions are possible.

Only for short maturities, however, is it possible to find a perfect match of maturities in the spot and futures markets. For example, from March 24 through June 22, 1977, spot bills due June 23 and September 22 and June futures provided instruments with exactly matching maturities. Settlement on the June futures took place on June 23, and required delivery of the September 22 bill—a 91-day bill on June 23—on all June futures contracts still open. If held to maturity,

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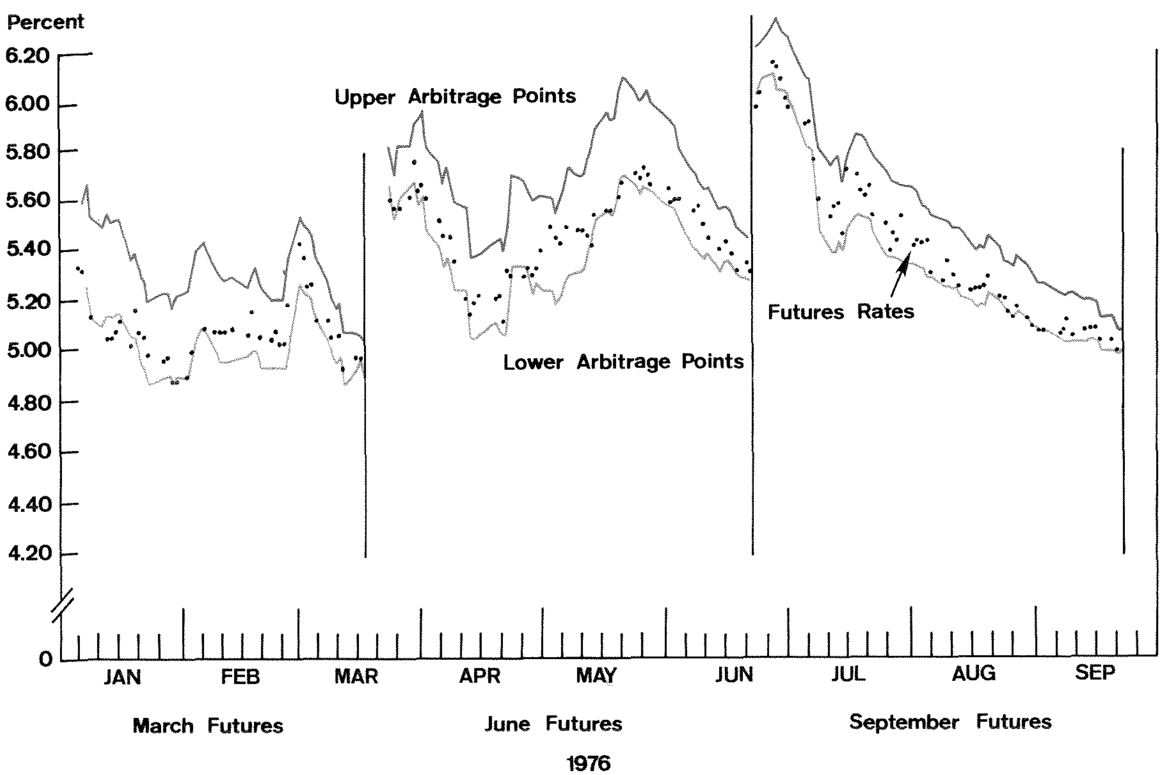
an investment in the combination package of the June 23 spot bill and a long position in June futures had identical characteristics to an investment in the September 22 spot bill. The two investments should, therefore, have identical yields—except for possible differences in transactions costs should the investor desire to sell out before maturity. The yield differences are limited, however, by the possibility of arbitrage between the two markets.

Arbitrage opportunities for futures maturities other than the nearest one are not quite risk-free because the maturities do not quite match. For example, between December 23, 1976 and March 22, 1977, arbitrage involving June 1977 futures had to be based on bills dated September 20 and June 23; the September 22 bill was not issued until March 24.

In studying the completeness of arbitrage, we may limit the investigation to the nearest maturity futures contract, so as to avoid the need for extra assumptions concerning arbitrage when maturities do not quite match. In examining arbitrage, we may proceed as if the spot bill yields are fixed; the problem is the determination of the range of bill futures yields such that risk-free arbitrage profits are possible considering the explicit transactions costs involved. The range will be defined in terms of an upper critical point, F^U, above which substitution of the short spot bill and a long futures position for the long spot bill will be profitable; and a lower critical point, F^L, below which substitution of the long spot bill and a short futures position for the short spot bill will be profitable. Although we will be determining upper and lower critical points for the futures rate given the spot bill yields, we could just as well have determined upper and lower critical points for either spot bill given the yield on the other bill and the futures yield.

In the derivations below it is assumed that bills are infinitely divisible, and all calculations are per $100. In fact, the discreteness of bills and of futures contracts—each futures contract is for $1 million face value of bills—prevents arbitrage from being profitable precisely at these critical points. However, the critical points derived under the perfect divisibility assumption provide

Chart 1



benchmarks against which the market may be judged with respect to the exhaustion of arbitrage opportunities.

Suppose that an n+91-day bill is owned, where n is the number of days to the maturity of the nearest futures contract. If the futures yield is high enough, the investor can raise his rate of return over the n+91-day horizon by selling the n+91-day bill and using the proceeds to buy an n-day bill and a long position in a futures maturing in n days. What futures yield will be high enough to make this substitution profitable?

Each n+91-day bill is worth $P^b_{n+91,t}$ at time t, where P^b is the dealer's bid price—the price at which investors other than dealers can sell the bill. By the definition of the banker's discount yield—the quotation method used in the bill market—we have

$$P^b_{n+91,t} = 100 - \frac{n+91}{360} R^b_{n+91,t}$$

where R^b is the bid yield, in percent, on the banker's discount basis. In the arbitrage transaction being examined, enough n+91-day bills are sold to buy the n-day bills required to provide the cash needed in n days to settle the maturing long futures position. The cash requirement at time t also includes the futures market commission—$60 per contract—and the futures market margin requirement—$1500 per contract. Since each contract is for $1 million face value of bills, the commission and margin amount to only $0.006 and $0.15, respectively, per $100 of face value.[2]

Working backwards, in n days the amount needed to settle the long position in the futures market will be

$$q_{n,t} = 100 - \frac{91}{360} F_{n,t}$$

where $F_{n,t}$ is the yield at time t on the futures contract maturing in n days. However, when the futures contract matures, the $1500 per contract margin will be returned, and so the net cash requirement per $100 in n days is $q_{n,t} - 0.15$.

Each n-day bill will be worth 100 upon maturity in n days; thus a $(q_{nt,} - 0.15)/100$ fractional n-day bill must be purchased at time t to provide the cash needed at time t+n. For investors other than dealers, the purchase price of an n-day bill is the dealers' asked price, $P^a_{n,t}$, which is related to the asked yield by

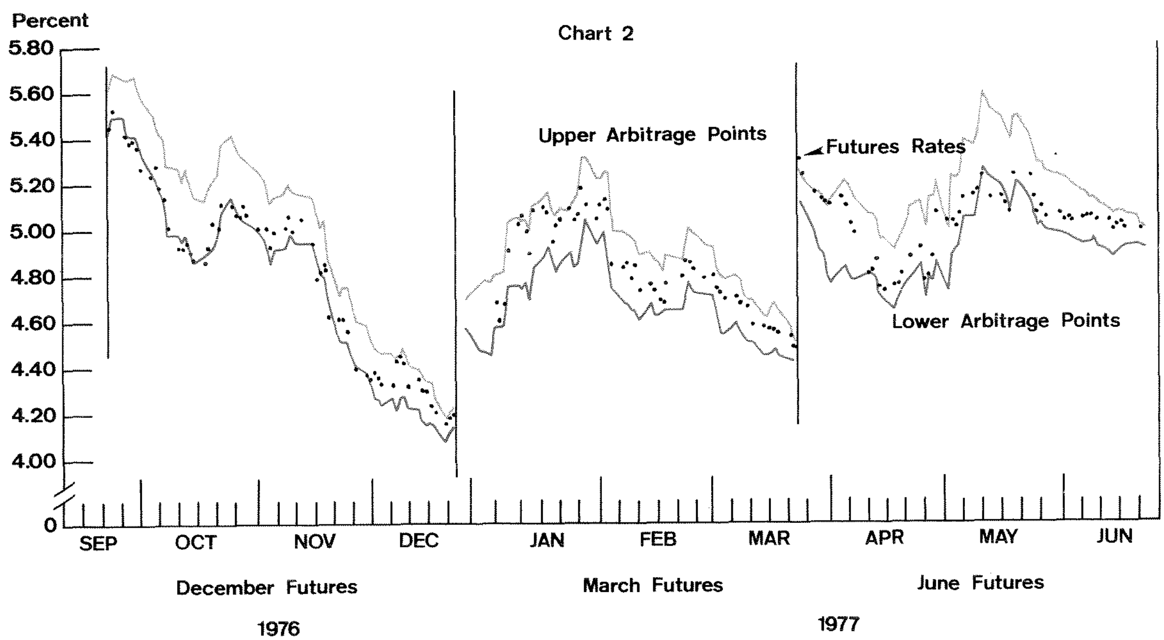
$$P^a_{n,t} = 100 - \frac{n}{360} R^a_{n,t}.$$

Thus, the cash needed at time t is that required to buy the fractional bill at the price of $P^a_{n,t}$ per bill plus the amount needed for the futures contract margin requirement and commission, or $0.15 and $0.006 per $100. Thus, the total cash requirement at time t is

$$\left(\frac{q_{n,t} - 0.15}{100}\right) P^a_{n,t} + 0.15 + 0.006.$$

The cash requirement at time t is to be raised by selling a fractional part, X, of the n+91-day

Chart 2



bill already owned. If this fraction is less than one, then the arbitrage operation will be profitable. The purchase of the n-day bill and the futures contract package will produce $100 in n+91 days. Simply holding the n+91-day bill will also produce $100 in n+91 days. Thus, if the arbitrage transaction requires that a fraction less than one of the n+91-day bill be sold, then the fraction 1-X of an n+91-day bill will be a risk-free arbitrage profit.

From these considerations, the fraction, X, of n+91-day bills selling at price $P^b_{n+91,t}$ sold must be such that

$$X\,P^b_{n+91,t} = \left(\frac{q_{n,t} - 0.15}{100}\right) P^a_{n,t} + 0.15 + 0.006.$$

Dividing through by $P^b_{n+91,t}$ defines X; arbitrage is profitable if X < 1, or in yield terms,

$$(1)\quad F_{n,t} > \left(1 - \frac{n}{36000} R^a_{n,t}\right)^{-1} \left[\frac{n+91}{91} R^b_{n+91,t} - \frac{n}{91} R^a_{n,t} + \frac{360}{91}(0.006) + \frac{n}{91}(0.0015\,R^a_{n,t})\right].$$

The right-hand side of the inequality (1) defines the upper critical point for profitable arbitrage. The expression has been written so that the components due to explicit transactions costs in the futures market—the terms involving 0.006 and 0.0015—may be clearly identified.

It may also be noted that without the two futures market transaction-cost terms, the right-hand side of (1) defines the implicit forward rate of interest in the term structure calculated from the bid yield on the n+91-day bill and the asked yield on the n-day bill. In the example being discussed, the implicit forward rate is the rate of interest that would have to be earned on a 91-day bill to be issued at time t+n, so that the total yield over n+91 days would be the same on an n+91-day bill and on an n-day bill with the proceeds invested on maturity in a 91-day bill. The yield on a 91-day bill is, of course, unknown before the bill is issued, but the investor can (if desired) lock in a known yield by buying a bill futures contract. He can also lock in that yield implicitly by buying an n+91-day bill, provided he is willing to lock in the package combination of the equivalent of an n-day bill and the 91-day bill to be issued at time t+n.

From a similar line of reasoning, the lower critical point may be defined. A risk-free arbitrage opportunity exists if

$$(2)\quad F_{n,t} < \left(1 - \frac{n}{36000} R^b_{n,t}\right)^{-1} \left[\frac{n+91}{91} R^a_{n+91,t} - \frac{n}{91} R^b_{n,t} - \frac{360}{91}(0.006) - \frac{n}{91}(0.0015\,R^b_{n,t})\right].$$

The right-hand side of (2) defines the lower critical point for profitable arbitrage.

The critical points defined by (1) and (2) have been calculated from daily data for the period from January 6, 1976 to June 23,1977, and plotted as solid lines in Charts 1 and 2.[3] The futures quotes are plotted as dots in the charts.

The charts suggest that profitable arbitrage opportunities rarely exist, and when they exist are small in magnitude. This finding is especially significant because only explicit costs were included in the calculation of the arbitrage points—no allowance was made, for example, for the labor time of the arbitrageur—and perfect divisibility was assumed.

Two other features stand out in the charts. First, there appears to be a tendency for the futures rate to fall closer to the lower than the upper arbitrage point, especially in the first month plotted for each contract. Second, there seems to be a tendency for the futures rate to fall in the last month of trading for each contract. These observations are directly related to the nature of term premiums in interest rates for securities of various maturities.

II. Term Premiums and Bid-Asked Spreads[4]

It is now generally agreed that longer-term securities have systematically higher yields than shorter-term securities, the differences being labled "term premiums," or "liquidity premiums." The existence of term premiums had been widely assumed, and so recent empirical findings have seemed to confirm the theoretical expectation that risk aversion would cause longer-term securities to sell at higher yields on the average than shorter-term securities.

To this author's knowledge, however, the relationship of transactions costs to term premiums has never been carefully investigated. The data used in previous studies of the term structure have consisted either of points drawn free-hand through yield observations—the Durand and Treasury *Bulletin* yield curves—or means of bid and asked yields. Given the significant size of bid-asked spreads—especially for short-term securities—it is clear that transactions costs need to be examined carefully.

The second and third columns of Table 1 suggest that transactions costs may be related to estimated term premiums. These two columns are reproduced from Tables 5-3 and 6-12 in Richard Roll's study of the Treasury bill market.[5] (The other column in Table 1 will be discussed later.) The sharp drop in Roll's estimated marginal term premium—the average difference between the one-week implicit forward rate m weeks in the future and the one-week spot rate realized in m weeks—between the 13- and 14-week maturities appears to be suspiciously related to the sharp increase in the mean spread between the same two maturities. Before discussing this issue further, however, a review of some of the a priori arguments concerning term premiums will prove helpful.

As a matter of *arithmetic*, a given change in yield to maturity produces a larger change in the price of a longer-term security than in the price of a shorter-term security. As a matter of *fact*, long-term yields do not fluctuate as much as short-term yields, but the relative variability of long-term and short-term yields is such that the prices of long-term securities nevertheless fluctuate more than the prices of short-term securities; thus, the capital values of long-term securities are subject to more interest rate risk. If we assume that investors are risk averse, we would expect that the average yield on long-term securities will have to be higher to compensate investors for the greater risk.

Another argument suggesting the probable existence of term premiums depends on transactions costs. Consider the situation faced by a firm that temporarily has excess cash which it will need in m days. The firm could buy an m-day Treasury bill, which would mature just when the cash was needed.[6] Alternatively, the firm could buy a longer-term security and then sell it in m days. A firm that is not risk averse would compare the yield on the m-day bill with the expected yield over m days from buying an n-day bill, where n is larger than m, and selling it after m days. This yield would have to be calculated from the asked price of the n-day bill and the expected bid price of an n-m bill in m days.

Letting $P_{k,t}$ be the price at time t of a bill with k days to maturity, the continuously compound-

Table 1
Bid-Asked Spreads and Term Premiums

Weeks to Maturity	Mean Spread[a]	Term Premium Marginal[b]	Term Premium Average[c]
1	.2336	0	0
2	.1762	.00704	.00352
3	.1486	.0555	.0208
4	.1288	.168	058
5	.1121	.291	.104
6	.0993	.323	.141
7	.0893	.347	.170
8	.0813	.383	.197
9	.0753	.445	.224
10	.0695	.427	.245
11	.0649	.396	.258
12	.0580	.414	.271
13	.0424	.562	.294
14	.0843	.0403	.276
15	.0835	.0696	.262
16	.0831	.142	.254
17	.0822	.175	.250
18	.0810	.189	.246
19	.0788	.256	.247
20	.0762	.262	.248
21	.0734	.296	.250
22	.0710	.305	.252
23	.0681	.310	.255
24	.0620	.328	.258
25	.0555	.365	.262
26	.0415	NA	NA

NA: Not Available.

[a] Weighted (by number of observations) averages of mean spreads for March, 1959-December, 1961 and January, 1962-December, 1964 reported in Roll, R., *The Behavior of Interest Rates*, Table 5-3.

[b] For March, 1959-December, 1964, from Roll, Table 6-12.

[c] For maturity m, mean of marginal term premiums for maturities 1, 2, . . . , m.

ed yield to maturity is

$$R_{k,t} = \frac{365}{k}(\log 100 - \log P_{k,t}).$$

The expected continuously compounded holding-period yield ${}_nH^*_{m,t}$ from buying an n-day bill at the asked price $P^a_{n,t}$ and selling it m days later at the expected bid price $P^{b*}_{n-m,t+m}$ is

$$ {}_nH^*_{m,t} = \frac{365}{m}(\log P^{b*}_{n-m,t+m} - \log P^a_{n,t})$$
$$= \frac{n}{m} R^a_{n,t} - \frac{n-m}{m} R^{b*}_{n-m,t+m}$$

The firm needing cash in m days will buy an m-day bill rather than an n-day bill if $R^a_{m,t} > {}_nH^*_{m,t}$. Using the definition of the bid-asked yield spread S_k on a bill with k days to maturity as the difference between the bid and asked yields, this inequality yields the expression

$$(3)\quad R^a_{m,t} > \frac{n}{m} R^a_{n,t} - \left(\frac{n-m}{m}\right)(R^{a*}_{n-m,t+m} + S^*_{n\text{-}m,t+m}).$$

A particularly convenient interpretation of inequality (3) arises for n = 2m. In this case, we have

$$(4)\quad R^a_{m,t} > 2R^a_{2m,t} - (R^{a*}_{m,t+m} + S^*_{m,t+m}).$$

Suppose interest rates on particular maturities are not expected to change so that $R^{a*}_{m,t+m} = R^a_{m,t}$, and suppose that bid-asked spreads for given maturities are constant over time so that $S^*_{m,t+m} = S_m$.[7] Then we can write (3) as

$$(5)\quad R^a_{m,t} > R^a_{2m,t} - \frac{1}{2} S_m.$$

Letting $R_{k,t} = \frac{1}{2}(R^b_{k,t} + R^a_{k,t})$
$= R^a_{k,t} + \frac{1}{2} S_{k,t},$
(5) may be written in terms of yields defined as the means of bid and asked yields.

$$(6)\quad R_{m,t} > R_{2m,t} - \frac{1}{2} S_{2m}.$$

Since bid-asked mean yields have typically been employed in term structure studies (including Roll's), (6) is in a form that relates the present argument to previous work. The typical finding that short-term rates are on the average below long-term rates is consistent with (6) provided that the yield differential is not excessive compared to the spread. The average difference between the yield to maturity on an m-week bill and the yield on a one-week bill is the average of the marginal term premiums for maturities 2, 3, . . ., m. This average term premium, calculated from Roll's estimates of marginal term premiums, is reported in Table 1. Using these estimates of average term premiums for various maturities and the estimated spreads in Table 1, inequality (6) is found to hold for maturities of 1, 2, 9, 10, 11, and 12 weeks but not for maturities of three through eight weeks.

It is interesting to note that Roll found the hypothesis of market efficiency well-supported except for maturities of 4 to 8 weeks.[8] For these maturities yields seem to be too low, on the average. We may conjecture, however, that the apparent anomaly would disappear with a fuller accounting of transactions costs.

A few numbers will provide a feel for the magnitudes involved. From inequality (6), the yield on a four-week bill is too low by about 10 basis points according to Roll's evidence. (A basis point is .01 percent.) Comparing the two sides of inequality (3) and using the fact that $R^a_m = R_m - 1/2\ S_m$, this 10 basis point discrepancy makes the right-hand side of (3) larger than the left-hand side by about 20 basis points. The firm with cash to invest for four weeks could, therefore, have a 20 basis points advantage on the average from investing in an eight-week bill (which would be sold after four weeks) rather than in a four-week bill.[9] These yields, however, are all expressed at annual rates. The yield advantage per four weeks is only 4/52 of 20 basis points, or about $154 per million of invested funds. It is easy to imagine that the extra transactions costs from buying an eight-week bill and selling it four weeks later as compared to simply buying a four-week bill and holding it to maturity would exceed $154 per million of funds invested.

The analysis of the transaction-cost effect in depressing yields on very short-term bills is, however, only indirectly relevant to the issue of the size of term premiums in bill futures-market quotes. We need to know whether the term premium should be subtracted in order to interpret the futures quotes as reflecting market expectations of future spot rates on three-month bills; the fact that a one-week bill has an average yield below that on a 13-week bill is not directly relevant to this issue.

The transaction-cost argument suggests that yields on very short-term bills could be depressed without there being any noticeable impact on longer-term bills. For example, in comparing the yield from holding a 13-week bill to maturity with the yield from holding a 26-week bill for 13 weeks, the bid-asked yield spreads are small enough, and the 13-week holding period long enough, so that there is little room for the average 13-week bill yield to fall below the average 26-week bill yield. From inequality (6) and the mean spread on 26-week bills (Table 1), the effect would be only two basis points.

Nevertheless, the transaction-cost effect on very short-term bills can affect term premiums (as estimated in previous studies) because of the way in which implicit forward rates are calculated. To understand the argument, consider first the expression defining the implicit forward rate of interest on a 13-week loan to begin m weeks in the future, calculated from the yields to maturity on spot bills with m and m+13 weeks to maturity. Using continuously compounded yields,

$$(7) \quad {}_{13}r_{m,t} = \left(\frac{m+13}{13}\right) R_{m+13,t} - \frac{m}{13} R_{m,t},$$

where ${}_{13}r_{m,t}$ is the implicit forward rate as of time t on a 13-week loan to begin in m weeks and $R_{k,t}$ is the yield to maturity on a spot bill with k weeks to maturity. On the average, the yield on a k-week bill exceeds the yield on a one-week bill by the average term premium $\overline{L}_k$. Thus, on the average we have

$$\begin{aligned}(8) \quad {}_{13}r_{m,t} &= \left(\frac{m+13}{13}\right)(R_1 + \overline{L}_{m+13}) \\ &\quad - \frac{m}{13}(R_1 + \overline{L}_m) \\ &= R_1 + \left(\frac{m+13}{13}\right)\overline{L}_{m+13} - \frac{m}{13}\overline{L}_m \\ &= R_1 + \frac{1}{13}\sum_{j=m+1}^{m+13} L_j.\end{aligned}$$

The third line in equation (8) is derived from the definition

$$\overline{L}_k = \frac{1}{k}\sum_{j=1}^{k} L_j.$$

Each L_j, it may be recalled, is the marginal term premium—the amount by which the implicit forward rate on a one-week loan to mature k weeks in the future exceeds the realized spot rate on a one-week loan maturing k weeks in the future.

The summation term in (8) contains 13 L_j's. If the L_j's were nondecreasing so that $L_{j+1} \geq L_j$, then

$$\frac{1}{13}\sum_{j=m+1}^{m+13} L_j \geq \frac{1}{13}\sum_{j=1}^{13} L_j = \overline{L}_{13}.$$

In this case the implicit forward rate ${}_{13}r_{m,t}$ would be an upward biased estimate of $R_{13} = R_1 + L_{13}$.

Roll's estimates of the L_j, however, are not nondecreasing for all j. When the summation term in (8) is calculated using Roll's estimates it is found that ${}_{13}r_m$ is an upward biased estimate of R_{13} for m from 1 to 7 weeks but a downward biased estimate for m from 8 to 12 weeks. The maximum size of the downward bias is about four basis points and the maximum size of the upward bias is about two basis points. While the size of the upward bias is very small based on Roll's estimates, the phenomenon may help to explain the appearance in the charts of a decline in the implicit forward rates underlying the arbitrage points in the last month of trading of a futures contract.

McCulloch provides another term-structure study of direct relevance to this issue.[10] Using somewhat different estimation methods than Roll and a sample period from March 1951 to March 1966, McCulloch reports estimates of the term premium attached to implicit forward 13-week rates various periods in the future (Table 2). If these estimates are taken at face value, 10 to 20 basis points should be subtracted from implicit forward rates for 13-week bills one or more months in the future to obtain market expecta-

Table 2

McCulloch Estimates of Term Premiums in 13-week Implicit Forward Rates

	Term Premium	
Bill to be Issued in:	**Free Form Estimates**	**Exponential Form Estimates**
1 month	0.10	0.09
2 months	0.15	0.14
3 months	0.16	0.17
6 months	0.12	0.21
9 months	0.11	0.22
1 year	0.13	0.22
2 years	0.12	0.22

tions of future spot rates on 13-week bills.

These estimates of term premiums are above those relevant for the bill futures market if the argument on transaction costs is accepted, because transaction costs affect implicit forward rates calculated from spot bills of varying maturities but not the bill futures market. If this argument is correct, quotes in the futures market should generally be below the corresponding implicit forward rates.

This hypothesis was tested by calculating the mean futures rate and the mean implicit forward rate over the three-month period preceding the maturity date of the six futures contracts maturing between January, 1976 and June, 1977 (Table 3).[11] In every case the mean of the rate on a given futures contract is below the corresponding mean of the implicit forward rate calculated from bid-asked mean rates. The means of the upper and lower arbitrage points are also reported, although it is obvious from the charts that the futures rate almost always lies between the two arbitrage points.

A test of the statistical significance of the results in Table 3 is reported in Table 4. The test has been confined to the first 20 observations in each of the periods listed in Table 3, since there is much more interest in market forecasts of the bill rate a few months in the future than in forecasts a few weeks in the future. For the first 20 trading days in each period, the difference between the futures rate and the implicit forward rate was calculated; the means and standard deviations of these differences appear in Table 4 along with the statistic for testing the statistical significance of the mean difference. The mean difference is negative for all periods. Using a one-tailed t-test, the mean differences for the first, second, and fourth periods are significant at the .001 level, the third period at about the .02 level, the fifth period at almost the .05 level, and the last period at about the .15 level. From these results for the individual periods, it is obvious that, in the pooled sample for the six periods combined, the mean is statistically different from zero at a very high level of statistical significance.

The evidence suggests that yields on very short maturities are depressed by the existence of transaction costs. Investors depress the return on very short-term bills when they attempt to obtain a return on balances invested for only a few weeks' time. The return is apparently slightly lower than can be explained by the bid-asked spreads on longer-term bills, but not by much.

Table 3

Means of Futures Rates, Implicit Forward Rates, and Arbitrage Points for Selected Periods

			Implicit Forward Rate			Arbitrage Point	
Period	**Futures Contract**	**Futures Rate**	**Bid-Asked Mean**	**Bid**	**Asked**	**Lower**	**Upper**
1/6/76-3/17/76	March 1976	5.10	5.17	5.21	5.13	5.02	5.32
3/24/76-6/23/76	June 1976	5.48	5.54	5.57	5.50	5.38	5.69
6/24/76-9/22/76	Sept. 1976	5.42	5.45	5.49	5.42	5.34	5.57
9/23/76-12/22/76	Dec. 1976	4.84	4.95	4.98	4.92	4.84	5.05
12/23/76-3/23/77	March 1977	4.82	4.85	4.87	4.82	4.73	4.96
3/24/77-6/22/77	June 1977	5.05	5.11	5.12	5.10	4.99	5.23

Table 4

Futures and Implicit Forward Rates
(Differences, first 20 observations each period)

Differences	1/6/76- 3/17/76	3/24/76- 6/23/76	6/24/76- 9/22/76	9/23/76- 12/22/76	12/23/76- 3/23/77	3/24/77- 6/22/77
Mean, $\bar{X}$	−0.1345	−0.0505	−0.0285	−0.1590	−0.0405	−0.0205
Standard Deviation, S	0.0788	0.0511	0.0584	0.0397	0.1079	0.0894
Test Statistic, $\lvert \bar{X}/S\sqrt{20} \rvert$	7.63	4.42	2.18	17.91	1.68	1.03

The term premiums involved, however, do not in any event extend very far into the yield structure. Beyond maturities of about 13 weeks, the average term structure is essentially flat.

Quotes on the nearest maturity in the bill futures market can, therefore, be interpreted for all practical purposes as the market's unbiased estimates of the future spot rates on 13-week bills. The policy significance of this finding will now be explored.

III. Policy Implications of T-Bill Futures

The evidence discussed above shows that for the nearest bill futures maturity there is a close correspondence between the futures rate and the implicit forward rate calculated from spot rates. If this finding also applies to the other bill futures maturities—and in this section it will be assumed that the finding does apply to all maturities—then it is clear that the opening of the bill futures market did not provide policymakers with much new information. Nevertheless, the futures rates, by displaying investors' expectations of future spot rates on 13-week bills explicitly, have focused attention on these expectations in a way implicit forward rates never did.

Since the start of trading in bill futures in January, 1976 the rates on more distant futures have always been higher than the rates on near futures; investors have been expecting spot bill rates to rise over time. As of this writing—early April, 1978—realized bill rates have been almost always below prior expectations as measured by rates on the more distant futures contracts. For example, on January 30, 1976 the futures rates for March, June, September, and December, 1976 were 4.89, 5.33, 5.64, and 5.86 percent, respectively.[12] The realized bill rates on the maturity of these futures were 4.97, 5.32, 5.01, and 4.25 percent, respectively. For a more recent example, on September 30, 1976 the futures rates for December, 1976, March, June, September, and December, 1977, and March, 1978 were 5.37, 5.71, 6.07, 6.44, 6.77, and 7.10 percent, respectively, whereas the realized spot rates were 4.25, 4.52, 5.00, 5.85, 5.96, and 6.22 percent, respectively.

If the findings in the previous section apply to all futures maturities, then the differences between the futures rates and the realized spot rates over the last two years reflect genuine expectational errors rather than term premiums attached to the futures rates. A variety of interpretations of these expectational errors is possible.

One starting point would be a hypothesis concerning the relationship between economic activity and inflation on the one hand and the spot bill rate on the other. It is generally argued that higher levels of economic activity add to the demand for funds to finance business inventories, purchases of consumers' durables, and so forth, and so tend to raise interest rates. Higher rates of inflation also tend to raise interest rates. Expectational errors, therefore, could have occurred if economic activity and the inflation rate had been below investors' anticipations. This explanation seems not very satisfactory, however, because the performance of the economy over the past two years has, if anything, been slightly stronger than earlier forecasts had suggested likely.

Another possible explanation of expectational errors emphasizes the influence of government policy on interest rates. In the short run, accelerated money growth probably tends to depress interest rates, and slower money growth to raise interest rates. If money growth is higher than anticipated, interest rates will tend to be lower than anticipated. Similarly, since government budget deficits require financing, smaller-than-anticipated budget deficits will tend to lead to lower-than-anticipated interest rates. Interpretation of the interest-rate effects of monetary policy is complicated, however, by the fact that higher money growth in the long-run raises the rate of inflation and, therefore, raises interest rates. It is not known exactly where the dividing line in time lies between the short-run effect of depressing interest rates and the long-run effect of raising interest rates.

The explanation for recent expectational errors that emphasizes errors in anticipating government policy fits the facts better than the explanation based on the performance of the economy. Money growth on the M_1 definition was higher in 1976 than in 1975, and higher in 1977 than in 1976; on the M_2 definition, money growth was higher in 1976 than in 1975, but lower in 1977 than in 1976.[13] And the total government-budget deficit—federal, state and local government combined—has been lower than anticipated by many observers because of below-budget federal spending and surprisingly large state-and-local budget surpluses.[14]

A third explanation—one consistent with much recent discussion—is that the demand for money may have declined over the past several years. Especially on the M_1 definition, money growth in 1975 and 1976 was much slower than would have been anticipated given the observed changes in income and interest rates. Or, viewed another way, interest rates were much lower than would have been anticipated given the observed growth in M_1 and income. From the point of view of a bill futures market participant in early 1976, the concensus forecast for income growth and the Federal Reserve's announced money growth targets implied, from the existing evidence on money demand relationships, higher interest rates than were in fact realized.

While this brief discussion may or may not be a correct analysis of the interest rate expectational errors of the past two years, it serves to introduce the nature of the problem faced by policymakers in interpreting the interest rate forecasts incorporated in T-bill futures rates. The key problem faced by policymakers is that of assessing the significance of market interest rate forecasts that differ from the policymaker's own forecasts.

Suppose, for example, that T-bill futures rates are higher than policymakers' forecasts of future interest rates. One possibility is that the market is anticipating a higher level of economic activity and/or a higher inflation rate than policymakers are anticipating. It is especially important to consider this possibility, because the market forecasts incorporated in bill futures rates reflect more than simply the interest-rate guesses of speculators. Firms may enter the bill futures market on the basis of their anticipated cash flows arising, for example, from the expected effects of current plans or commitments to accumulate inventories.

This type of activity in the bill futures market is similar to that in commodity futures markets; the wheat futures price, for example, reflects expected demands for wheat by bakeries and supplies of wheat by farmers. Trading in this market, therefore, reflects the impact of current decisions—bread supply commitments by bakeries and planting decisions by farmers—that will affect wheat supplies and demands and, therefore, wheat prices in the future.

If policymakers' forecasts of interest rates below those in the bill futures market do reflect mistaken forecasts by policymakers of the future strength of aggregate demand, then their decisions may provide for a more expansionary policy than is appropriate. The accuracy of the economic forecasts available to policymakers is not so high that the possibility that high futures rates are forecasting higher levels of economic activity and/or higher inflation can be ignored.

An even more troubling possibility, though, is that rates in the bill futures market may reflect anticipations concerning policy decisions that do not reflect actual policy plans. Failure of policy decisions to ratify private anticipations concerning policy then falsifies one of the assumptions under which business decisions are made and leads to less appropriate business decisions than would otherwise be the case.

To avoid private expectational errors, policymakers must provide clear information, through formal announcements or otherwise, concerning-prospective policies. And if statements concerning policy intentions are to be believed, policymakers must in fact determine policy in accordance with those announced intentions. If policies typically do not reflect previously announced policy intentions, then statements of policy intent will simply not be believed. Business planning will be subject to unnecessary uncertainty, but so also will policy planning. To interpret current economic data in such a situation, policymakers will have to guess what businessmen are guessing the policymakers will do.

An apparently easy solution to this problem would be for policymakers to make clear announcements of their policy plans and then to ensure that these plans are realized. Under this approach, however, policy could not be adjusted in a flexible and timely manner when economic conditions change unexpectedly. The policy dilemma is clear. To encourage sound and sensible business planning, policymakers need to make their plans clear and must realize their plans to retain credibility. But policy plans should, presumably, be adjusted from time to time to reflect changing economic conditions.

Different policy analysts place differing degrees of emphasis on the relative importance of realizing policy plans and of retaining policy flexibility. Unfortunately, there is no simple way of determining how to strike a balance between those two goals. What can be done, though, is to broaden the concept of the announced policy plan by making clear the nature of the policy responses to be expected under specified conditions. It is well understood, for example, that the Federal Reserve will intervene heavily to stabilize money markets disrupted by a spectacular bankruptcy such as the Penn-Central failure in 1970, even if such intervention produces a temporary surge in money growth far above what had been planned.

But it is important to distinguish between specific intervention of this type and a more generalized intervention to cushion interest-rate increases. An excellent example of the benefits of *not* cushioning interest-rate increases occurred in April 1977, when M_1 increased at a 20-percent annual rate (since revised to 14 percent). That episode raised fears in the markets that the Federal Reserve was permitting money to expand at a rate far above its announced policy intentions. By permitting short-term interest rates to rise sharply at that time—the 13-week bill rate went from 4.57 percent in the week ending April 1 to 5.06 percent in the week ending May 27—the Federal Reserve convinced the markets that money growth would not be permitted to continue at clearly excessive rates.

While the rate on 13-week bills was rising in May 1977 rates on the more distant bill futures fell. Comparing weekly average rates for the week ending April 1 to weekly average rates for the week ending May 27, the September 1977 futures went from 5.88 to 5.65, the March 1978 futures from 7.03 to 6.62, and the September 1978 futures from 7.83 to 7.22. In this situation, expanding the rate of money growth even further to hold down the rate on 13-week bills might very well have led to heightened fears of future inflation which would have raised rates in the futures market.

IV. Summary and Conclusions

The evidence reviewed in this paper demonstrates that the Treasury-bill futures market is closely linked to the spot market in Treasury bills. Unexploited arbitrage opportunities between the two markets rarely exist.

A key question is whether term premiums must be subtracted from T-bill futures rates to convert those rates into market forecasts of future spot rates on Treasury bills. A review of evidence on term premiums from previous studies suggests that very short-term bills trade at lower yields than longer-term bills on the average but that much, and perhaps all, of the average yield differential probably reflects the extra transactions costs from selling longer-term bills before maturity compared to holding very short-term bills to maturity. Because transactions costs in trading bill futures are so very small, futures rates were hypothesized to be slightly lower than the forward rate implicit in the yields on spot bills of various maturities. This hypothesis is supported by the evidence presented in this paper.

What is the policy significance of the new market in Treasury bill futures? The existence of these explicit market interest-rate forecasts emphasizes the need for policymakers to understand the reasons for discrepancies between their own interest-rate forecasts and market interest-rate forecasts. If, at some point in time, rates in the bill futures market are based on forecasts of a stronger and/or more inflationary economy than projected by policymakers, and if the market is correct, then there is a danger that policymakers will determine a more expansionary policy than is appropriate for the needs of the economy.

Market interest-rate forecasts may also reflect forecasts of policies that differ from those that policymakers are actually planning. This possibility emphasizes the importance of policymakers making their plans known and maintaining credibility by ensuring that announced policy plans are realized. However, strict adherence to policy plans makes it difficult for policy to be adjusted flexibly in response to changing circumstances.

While there is no easy solution to this dilemma, the problems raised can be eased by including in the concept of a policy plan an understanding of the policy adjustments required by certain contingencies. For example, permitting temporarily high money growth to cushion market disruptions caused by a major bankruptcy, such as the Penn-Central failure, need not imply that long-run plans for money growth will not be realized.

Although the accuracy of the bill futures rates as predictors of future spot rates was not discussed in detail, it is clear that futures rates, even if unbiased, are not especially accurate forecasts. For this reason the policy significance of these interest rate forecasts ought not to be exaggerated. However, the policymakers' own forecasts of interest rates are not very accurate either. Unless policymakers have solid evidence that their own forecasts are more accurate than market forecasts, they cannot afford to ignore the T-bill futures market.

FOOTNOTES

1. See, for example: Albert E. Burger, Richard W. Lang, and Robert H. Rasche, "The Treasury Bill Futures Market and Market Expectations of Interest Rates," **Federal Reserve Bank of St. Louis Review**, June, 1977; Wallace H. Duncan, "Treasury Bill Futures—Opportunities and Pitfalls," **Federal Reserve Bank of Dallas Review**, July, 1977; Paul L. Kasriel, "Hedging Interest Rate Fluctuations," **Business Conditions** (Federal Reserve Bank of Chicago), April, 1976; and Linda Snyder, "How to Speculate on the World's Safest Investment," **Fortune**, July, 1977.

2. The calculations discussed below are based on the assumptions that the $60 commission is paid when the futures position is taken and that the $1500 margin is put up in cash. In fact, the commission may in some cases be paid when the futures position is covered and the margin requirement may be satisfied by putting up interest-bearing securities. In addition, futures price fluctuations may lead to a requirement that additional cash or securities be added to the margin account or may permit some cash or securities to be withdrawn from the margin account. Because the amounts involved are so small, these considerations would have a negligible effect on the arbitrage calculations presented below and so are ignored.

3. The data base consists of closing bid and asked yields on bills, and closing futures quotes—all from the **Wall Street Journal.**

4. This section is somewhat technical and may be skipped by the reader primarily interested in the policy implications of the bill futures market.

5. Richard Roll, **The Behavior of Interest Rates** (New York: Basic Books, 1970).

6. Treasury bills, of course, do not mature every day. The firm wanting to invest in a maturing bill would have to select the existing bill with maturity best matching the firm's predicted cash needs. The following analysis ignores the fact that purchase of a bill with more than m days to maturity permits the firm to keep its

funds invested right to the day its cash needs arise, since an existing bill can be sold on any business day.

7. Rather than interpreting equation (4) as applying to a time when rates are not expected to change, the rates in (4) may be interpreted as the means of the rates over a long sample period in which there is no overall trend in the level of rates. The means of $R^a_{m,\,t+m}$ and $R^a_{m,t}$ differ only by virtue of one observation at each end of the sample.

8. See Roll, p. 116.

9. That the holding period yield advantage is greater than the discrepancy in yields to maturity can be seen readily from the fact that the yield to maturity, R_n, on an n-week bill is the weighted average of the yield over the first m weeks and the yield over the remaining n-m weeks. If the latter yield is below R_n, then the former yield must be above R_n.

10. J. Huston McCulloch, "An Estimate of the Liquidity Premium," **Journal of Political Economy,** 83 (February, 1975), 95-119.

11. The yields in Table 3 are bankers' discount yields. The implicit forward rates were calculated with due regard for discounting considerations.

12. The two longer futures contracts, March and June 1977, were not actively traded in the first several months after the futures market opened.

13. Measuring money growth from December of one year to December of the next, M_1 growth was 4.1 percent in 1975, 6.1 percent in 1976, and 7.7 percent in 1977, while M_2 growth was 8.5, 11.4, and 9.2 percent, respectively.

14. See Edward M. Gramlich, "State and Local Budgets the Day after It Rained: Why Is the Surplus So High," in Arthur M. Okun and George L. Perry, eds., **Brookings Papers on Economic Activity,** 1978:1, 191-214.

GNMA Futures: Stabilizing or Destabilizing?

Kenneth C. Froewiss*

On any list of the most controversial sectors of the U.S. economy, surely futures markets, financial markets, and the housing market would appear near the top. The housing sector has been the intended beneficiary of a wide variety of public programs. Financial markets have long been subjected to a myriad of government regulations. And futures markets have had to fight repeated attempts to legislate them out of existence.

The Chicago Board of Trade established a unique link among these three sectors in October 1975 when it inaugurated a futures market in the financial instruments of the Government National Mortgage Association (GNMA). This agency had designed its "pass-through" certificates—mortgage-backed bonds guaranteed by GNMA—in order to help the housing industry by attracting more investors to the mortgage market. Most economists would argue that the institution of futures trading in GNMA certificates should further that goal. Economic theory suggests that futures trading arises in markets characterized by large price variability and that it helps to reduce that variability.[1] By contrast, many non-economists believe that futures trading is a *cause* of greater price variability rather than a *response* to that variability. *Business Week* referred recently to ". . . the charge that futures markets themselves increase the volatility of commodity prices and that speculators are the chief culprits behind wild swings, often pushing prices in directions that are unwarranted by underlying economic conditions."[2]

If the establishment of a GNMA futures market increases the variability of GNMA spot prices, a number of investors might find GNMA certificates less attractive. Futures trading in GNMA's would then be at odds with the goal of increasing the liquidity of the mortgage market—a market in which GNMA securities are playing an increasingly important role. At the end of 1977, GNMA-back securities accounted for almost $44 billion of the $650 billion outstanding debt on one-to-four-family homes.[3]

There have already been charges that the "explosive growth" of the GNMA market has led to speculative excesses.[4] Presumably, the growth of a futures market will encourage even more speculative activity in this market. The purpose of this article is to determine whether futures trading in GNMA certificates has stabilized or destabilized GNMA spot prices. This question is important to policymakers charged with aiding the housing market as well as to those responsible for regulating futures trading. Furthermore, the question has implications for the other financial futures markets now in existence: Treasury bills, Treasury bonds, and commercial paper. The *Wall Street Journal* has noted government officials' concern that speculative activity in financial futures could disrupt the bond market.[5] Consequently, should the development of these futures markets be encouraged or discouraged? As in the case of the GNMA's, the answer partly depends on the extent to which futures trading affects spot prices.

A related and equally important policy issue is whether banks and thrift institutions should hold financial futures only for use in hedging activities. However, this article will not attempt to address that question.

Section I discusses the motivations which led to the development of the GNMA futures market. Section II examines the theoretical basis for the belief that speculation will tend to stabilize rather than destabilize prices. Section III presents the results of alternative empirical tests of the effect of GNMA futures on the spot market. Section IV summarizes the principal findings, which support the position that futures trading has had, if anything, a stabilizing influence on the spot prices of GNMA certificates.

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I. Development of the GNMA Futures Market

The GNMA futures market is the result of two separate developments, both dating back to the late 1960's. The first was the mortgage industry's attempt to devise a hedging mechanism to protect itself from unforeseen interest-rate fluctuations. The second was GNMA's introduction of a new security to attract more investors to the housing market.

Mortgage hedging[6]

The possibility of unforeseen price changes makes holding inventories of any good a risky business. Since many people are willing to pay a price to exchange risk for certainty, organized futures markets exist so that holders of inventories can hedge against the risks of price changes.[7] For example, when a warehouse purchases grain, it may simultaneously enter into a futures contract to lock in the price at which it can sell that grain at a later date.

Until the 1960's, futures trading in the United States was concentrated in grains and the soybean complex. But during the next decade, futures contracts were added in a number of other "commodities," ranging from plywood to pork bellies. And just when the exchanges began looking for new markets to enter, real-estate investors began discussing the feasibility of a futures market to hedge against interest-rate risk.

Actually, economists at a much earlier time had used the analogy between the markets for financial instruments of varying maturities and the commodity futures markets to explain the term structure of interest rates.[8] But now people were beginning to discuss the practical problems of setting up an interest-rate futures market. They were motivated to do so by the sharp rise in interest rates in 1969, and by the resulting losses incurred by fixed-income security holders in general and by mortgage lenders in particular.

Mortgage bankers and mortgage-originating savings-and-loan associations stand to lose money if interest rates rise between the time at which they commit their funds and the time at which they sell the mortgages. Their situation is exactly analogous to that of the grain elevator which temporarily holds wheat bought from farmers before selling it to millers. The biggest difference between the two groups is that the latter deals in a homogeneous commodity for which it is easy to set standards, while the former deals in a "commodity" (i.e., mortgages) which varies tremendously in quality and in exact specifications. This lack of homogeneity among mortgages was one of the greatest obstacles to the establishment of a mortgage-futures market.[9]

GNMA certificates

At the same time that the real-estate community was attempting to find a way to hedge mortgage-interest risks, the Government National Mortgage Association—created by the Housing Act of 1968 as part of the Department of Housing and Urban Development—was attempting to help the housing market by making mortgages more attractive to all types of investors.[10] Both groups faced the same key problem: the lack of homogeneity across mortgages. Many investors, lacking the necessary ability to gauge the quality of particular mortgages, tended to avoid the secondary mortgage market. Individual investors were further dissuaded by the large volume of funds which would be needed to purchase a reasonably well-diversified portfolio of mortgages. As a result, the secondary mortgage market lacked the depth of, say, the secondary government-bond market. During periods of high interest rates, whenever thrift institutions tried to sell mortgages out of their portfolios to offset deposit outflows, they were forced to accept unfavorable terms because of the thinness of the secondary market. In view of this problem of raising funds, they found it difficult to continue making new mortgage loans during tight-money periods.

The GNMA modified pass-through certificates represented a means of easing this difficulty.[11] Introduced in early 1970, these certificates enable an individual investor to purchase a share in a pool of FHA/VA insured mortgages, with payment of the interest and principal guaranteed by GNMA. The originator of the mortgages—typically a mortgage banker or savings and loan—packages them into a pool of at least $1 million and turns them over to a custodial bank. All of the mortgages must bear the same face rate of interest and have roughly the same maturity date. GNMA may then issue securities in amounts as small as $25,000 on the pool.

The coupon rate on the securities is 50 basis points less than that on the underlying mortgages. (Yield quotations on the securities are based on the assumption of prepayment in the 12th year.) The issuer of the securities receives 44 basis points as a management fee—for collecting the monthly mortgage payments, "passing-through" the payments to the security holders, and for dealing with any delinquent loans or foreclosures. Even if the issuer does not receive all of the monthly payments due him, he remains responsible for seeing that the security holders get their full payments on time. (It is this feature that gives rise to the name "modified" pass-through security.) GNMA itself guarantees timely payment to the security owners in the event of a default by the issuer, for which service it receives 6 basis points.

GNMA securities therefore have three levels of guarantees. The underlying mortgages are all FHA- or VA-insured. The issuer of the securities guarantees payment of principal and interest whether or not he receives his payments on time. And GNMA stands behind his guarantee with the full faith and credit of the U.S. Government. Thus, GNMA securities allow an investor with no specialized knowledge of mortgages to participate in the secondary mortgage market with virtually no fear of default risk.

Forwards and futures

The introduction of GNMA certificates not only helped to broaden the secondary mortgage market; it also suggested a solution to the problem faced by those attempting to create a mortgage futures market. Rather than deal directly in mortgages, market participants might trade GNMA securities of some designated denomination. Indeed, several years before the approval of organized *futures* trading, the market developed informal *forward* trading in GNMA securities.[12]

Forward trading and futures trading are not the same thing, despite a number of similarities. Whenever two people agree now to the terms of a transaction which will take place sometime later, forward trading can be said to exist. For example, when a mortgage banker begins the months-long process of assembling a pool of mortgages for conversion into a GNMA certificate, he might negotiate with, say a life insurance company regarding the price at which he will sell that security at some specified future date. Such forward contracts became increasingly common as mortgage lenders attempted to hedge against interest-rate risk—but they did not constitute a futures market.

A forward contract is an agreement between two individuals, tailored to their particular needs. A futures contract is a standardized agreement, traded on an organized exchange, in which the exchange itself is the opposite party in every contract. Telser and Higinbotham express the difference as follows:

> "In a forward contract, the actual identity of the buyer and seller is important. Neither has recourse in case of dispute to a third party other than a court of law. The validity of the forward contract depends on the good faith of the two parties themselves. A futures contract has a third party, the organized exchange or its designated representative, that guarantees the validity of the contract and will enforce the terms."[13]

With contracts standardized and with the entire exchange standing behind each agreement, futures contracts are much more liquid instruments than forward contracts. As a result, the transactions costs involved in divesting oneself of a futures contract are generally less than for a forward contract. The greater expense of finding a buyer for an individually-tailored forward contract tends to limit the sale of such contracts to individuals who actually plan to take physical possession of the underlying commodity. But futures-market participants also include a large number of speculators who are willing to incur the price risks of buying and selling futures contracts but who never want to take or to make delivery. Because of the presence of these speculators, futures markets have a greater breadth than forward markets, with consequent expanded possibilities for hedging.

Nonetheless, futures markets often evolve out of forward markets. In the case of GNMA securities, this evolutionary process was aided by the passage of the Commodity Futures Trading

Commission Act of 1975, which provided the legal basis for the establishment of a formal interest-rate futures market. In October of that year, trading in GNMA futures contracts began on the Chicago Board of Trade.

Each contract confers the right to buy or sell a GNMA certificate with $100,000 in principal balance and an 8-percent coupon at some specified future date. (Actual delivery may be made using certificates with another coupon rate, in which case the principal balance is adjusted accordingly.) It is currently possible to enter into contracts up to almost three years into the future.

Trading in GNMA futures has grown very rapidly. In 1977, over 422,000 contracts changed hands, compared to less than 129,000 during 1976, the first full year of trading. Open interest in GNMA futures (the number of contracts outstanding) rose to almost 21,000 by the end of 1977, over four times the level of a year earlier.[14] But the futures market, not surprisingly, has by no means replaced the forward market. The two markets typically coexist during the early stages of development of a futures market, and they may coexist indefinitely.

A number of recent articles have described how the GNMA futures contract may be used for hedging.[15] The question here, however, is not the usefulness of GNMA futures to *individual* hedgers, but rather the impact—if any—of futures trading on the *spot market*. Has the futures market been "too successful" in attracting speculators, so that they, rather than hedgers, dominate the setting of futures prices? To determine how much truth there is in that popular fear, let us take a look, first, at the economic theory of speculation, and second, at the empirical evidence in the case of GNMA futures.

II. The Economics of Speculation

Basically, although speculation usually occurs in markets characterized by a relatively large amount of price variability, it is the *result* not the *cause* of that variability. This view was succinctly expressed by John Stuart Mill over a century ago:

> "These dealers [speculators] naturally buying things when they are cheapest, and storing them up to be brought again into the market when the price has become unusually high; the tendency of this operation is to equalize price, or at least to moderate its inequalities. . . Speculators, therefore, have a highly useful office in the economy of society; and (contrary to common opinion) the most useful portion of the class are those who speculate in commodities affected by the vissicitudes of the seasons."[16]

Speculation, of course, can occur apart from the existence of futures markets. In the above quote, Mill described the behavior of speculators who deal only in the spot market. But as we noted earlier, organized futures trading tends to encourage speculation. Speculation in futures markets can be carried out without any need to handle the commodities involved. Moreover, transactions costs in futures markets are very low, and capital requirements are small—at least compared with the costs of actually purchasing goods on the spot market and holding them in inventory.

Consequently, if speculation is socially beneficial, and if futures markets lead to more speculation than would otherwise occur, we may conclude that futures markets are useful to society as a whole, over and above their benefits to individual hedgers. Furthermore, their existence may help to reduce price fluctuations in ways other than those described by Mill. They may do so by improving inventory and production decisions—specifically, by providing information on the likely course of prices in months to come.[17] Holbrook Working has gone so far as to say that, "Today, the fact that futures trading provides central market prices established in open competitive bargaining may deserve to be regarded as the chief merit of futures markets from the public standpoint."[18]

But what if speculators forecast badly? Might they not then affect prices perversely, increasing their variability and reducing their usefulness as a source of information to direct the allocation of resources? Milton Friedman, in an often-quoted passage dealing with foreign-exchange speculation but applicable to any commodity, argued that any such tendencies could not persist for long:

> "People who argue that speculation is generally destabilizing seldom realize that this is largely equivalent to saying that speculators lose money, since speculation can be destabilizing in general only if speculators on the average sell when the currency is low and buy when it is high."[19]

Presumably, such speculators would be speedily eliminated from the market, leaving only those with superior foresight.

However, Friedman was careful to add a qualification, which is less often quoted: "A warning is perhaps in order that this is a simplified generalization on a complex problem."[20] Friedman himself conceded the possibility, earlier suggested by Kaldor, that destabilizing speculation might persist if a small body of professional speculators made money while a continually changing group of amateurs regularly lost larger sums. The successful speculators would still be the ones with superior foresight, but they would use their forecasting skills to predict the psychology of other speculators. As Kaldor argued:

> "In such circumstances, even if speculation as a whole is attended by a net loss, rather than a net gain, this will not prove, even in the long run, self-corrective. For the losses of a floating population of unsuccessful speculators will be sufficient to maintain permanently a small body of successful speculators; and the existence of this body of successful speculators will be a sufficient attraction to secure a permanent supply of this floating population."[21]

In Kaldor's scenario, it is profitable for professional speculators to act in a destabilizing manner—buying even when they consider prices to be too high in terms of non-speculative underlying trends—as long as they believe that they will be able to sell at even higher prices to other speculators. When the psychology of the market changes, the hapless amateurs are left with the goods, which they must sell at a loss. These unsuccessful speculators are then eliminated from the market, but a fresh group is always available to support the next speculative boom.

Other economists have also attempted to argue that destabilizing speculation can be profitable.[22] But the possibility described by Kaldor, in which speculators devote their efforts to outwitting each other, probably best accords with the popular suspicions about futures markets. These suspicions are buttressed by what Abba Lerner refers to as ". . . the hostility which people who have to work hard for their living often develop against the mysterious gains that speculators make in offices while dealing in goods which they would not even recognize."[23] Let us consider whether, in the specific case of GNMA futures, there is any factual basis for this anti-speculative attitude.

III. Empirical Evidence

Statistical tests for the effects of GNMA futures trading on GNMA spot prices face a fundamental limitation. We may be able to determine whether the behavior of spot prices has been different (in some suitably-defined way) since the start of futures trading, but we may never be able to ascribe such differences definitely to the existence of a futures market. They may merely reflect any of a number of changes which have occurred in the economy since futures trading began.

This problem is, of course, common to many economic studies, but it is particularly troublesome in the present context. Since October 20, 1975—the beginning of GNMA futures trading—the course of the U.S. economy in general and of financial markets in particular has changed considerably from what went before. But in addition, the GNMA pass-through is itself a relatively new financial instrument, so that the development of the GNMA futures market has coincided with the maturation of the GNMA spot market. As a result, any claims that changes in the spot market were *caused* by the establishment of a futures market would have to be accompanied by even more than the usual qualifications.

Graphic analysis

With those warnings in mind, let us analyze the actual behavior of spot GNMA prices during the periods before and after futures trading began. (Chart 1. Incidentally, the months immediately surrounding the start of futures trading have been omitted to remove any transitory disturbances associated with the opening of the new market.) Clearly, the average level of GNMA prices has been higher, and the variability about that average has been lower, since futures trading began. But it would surely be wrong to attribute those spot-market changes primarily to the futures market.

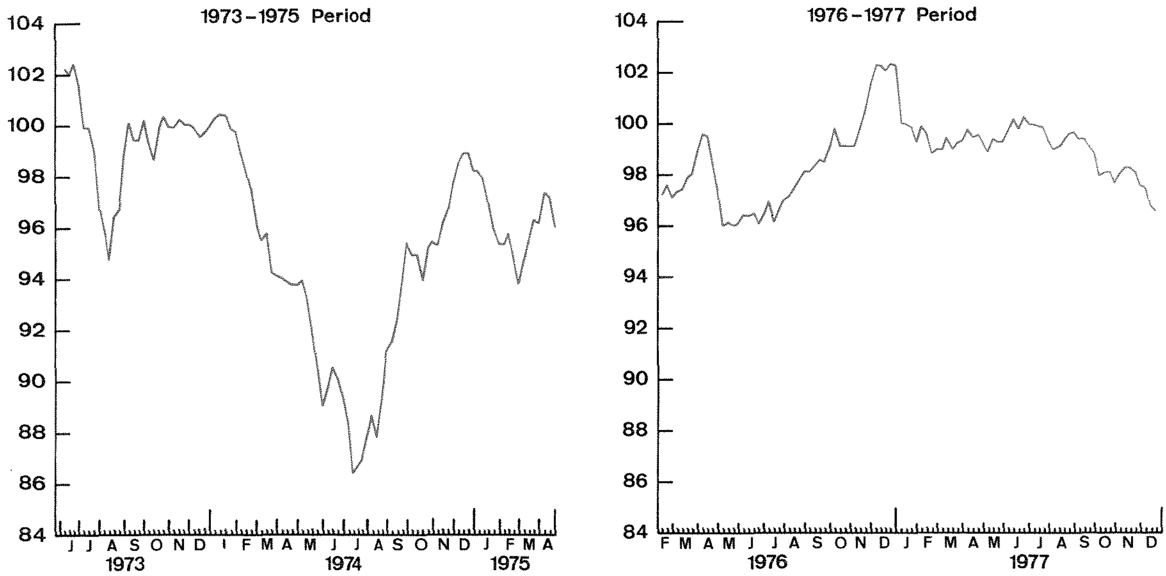
The broad movements in the level of spot prices are more reasonably explained as the normal market response to changes in the prices of long-term debt instruments which substitute for GNMA's in investor portfolios. Indeed, recent prices of GNMA's have roughly paralleled the prices of long-term government bonds. However, while it would be wrong to attribute the reduced variability in the level of GNMA spot prices to futures trading, it would similarly be unfair to blame futures trading for the wider swings in spot prices which would undoubtedly accompany another period of widespread greater variability in bond prices. The effects of futures trading—for good or ill—must be sought elsewhere.

One likely place to look would be the behavior of the *changes* in spot prices. Thus, while the overall trend in spot GNMA prices will be dominated by the overall movements in bond prices, futures trading might reduce the short-run variability in spot prices about that trend. It could do this by providing market participants with more information, in the form of instantly available price quotations on futures contracts, determined through competitive bidding in a centralized market. Armed with this additional information, investors in the spot market should be able to move prices more rapidly to their equilibrium values, thereby reducing the purely random movement in those prices.

An examination of the first differences in the weekly GNMA price series appears to bear out this hypothesis (Chart 2). The variability of the differences has declined markedly since the com-

Chart 1

GNMA SPOT PRICES



mencement of futures trading, especially when the sharp price movements of January 1977 are excluded. The graphical evidence, then, suggests that futures trading in GNMA's may have reduced the random variability in spot prices. But before drawing this conclusion, we should test statistically to determine whether the reduction in the week-to-week movements in GNMA prices again merely parallels a more general market trend.

Table 1
Responsiveness of GNMA Prices to Changes in Bond-Market Prices

Sample Period	Percentage Change in Government Bond Prices	Standard Error	Durbin-Watson
May 30, 1973- December 28, 1977	0.646 (15.1)	0.00541	1.78
May 30, 1973- October 15, 1975	0.637 (8.97)	0.00709	1.65
October 22, 1975- December 28, 1977	0.658 (16.7)	0.00302	2.37

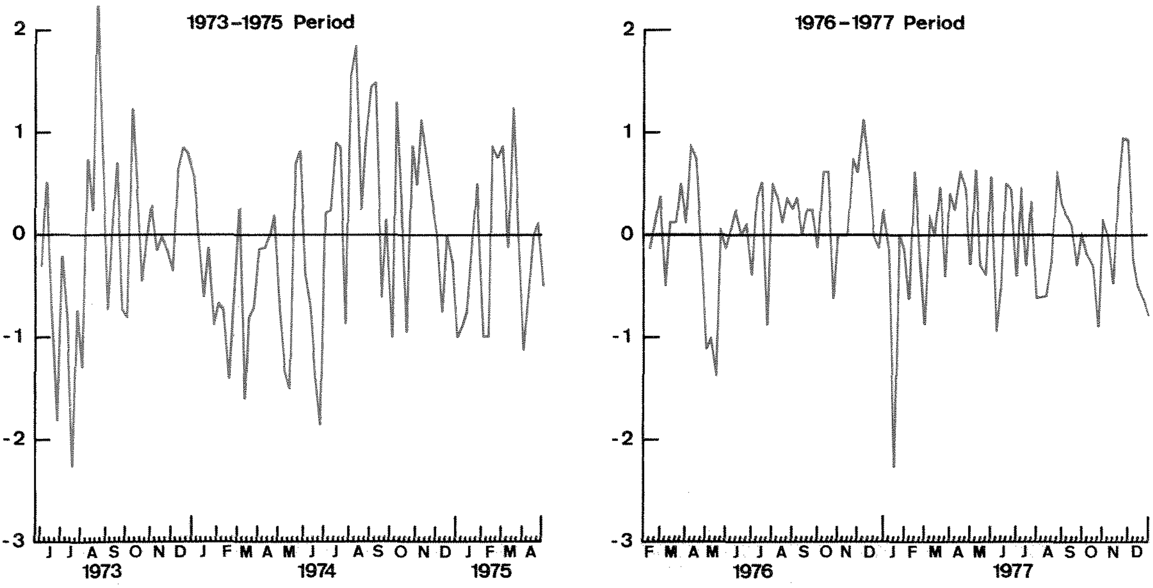
(Numbers in parentheses are t-statistics. None of the constant terms were significant, and were therefore not reported.)

Regression results

Our test involves regressing the weekly percentage changes in spot GNMA prices on the weekly percentage changes in the prices of ten-year U.S. Government bonds, which serve as a proxy for "the bond market." (The ten-year maturity was chosen because it approximates that of GNMA certificates, which are usually assumed to have an average life of 12 years.)[24] The coeffi-

Chart 2

FIRST DIFFERENCES OF GNMA SPOT PRICES



cient of the latter variable provides a measure of the variability of GNMA prices *relative* to the variability of bond prices generally. If the coefficient rises significantly after the beginning of futures trading, one could argue that futures trading tends to destabilize spot prices, increasing their relative variability and hence making GNMA's a riskier asset.[25]

The coefficient on the market index appears roughly constant in both the period before and the period after the beginning of futures trading. The standard F-test for the equality of coeficients confirms this impression (at the five-percent level of significance).[26] Therefore, the evidence in Table 1 suggests that futures trading has not made GNMA's more risky.

The standard error of the regression was much smaller in the second sub-period than in the first. Again, this impression is supported by the appropriate F-test, which indicates that (at the one-percent level) the standard error is significantly less in the later period.[27] Since a greater proportion of the week-to-week variance in GNMA prices can be explained by the movement of other bond-market prices following the start of futures trading, it appears that the GNMA market has become more integrated over time with the rest of the capital market.

Time-series analysis

As a check on these regression results, a Box-Jenkins analysis was utilized to measure the impact of GNMA futures trading.[28] As above, it is assumed that futures trading has a negligible impact on the *level* of GNMA prices—broad market forces cause the systematic movements in the spot price, but futures trading can affect the size of the random movements around the systematic trend. The time-series approach seeks to explain the systematic component of GNMA prices solely in terms of the past history of those prices.

An analysis of the autocorrelation structure of GNMA spot prices suggests that the series could be adequately represented as a second-order autoregressive process, i.e., current prices can be explained by the prices of last week—GNMA (−1)—and the week before—GNMA (−2)—plus a constant term (Table 2).

As in Table 1, F-tests indicate no statistically significant difference (at the five-percent level) between the coefficients in the two sub-periods, but they indicate a sigificantly smaller standard error of the regression in the second period (at the one-percent level).[29] We can thus infer that the systematic movements of GNMA prices have followed the same pattern in the period after as in the period before futures trading—as evidenced by the unchanged coefficients—but that the random fluctuations in spot prices have been reduced significantly.

In a final test, we regress the percentage weekly change in spot prices on the previous week's percentage change (Table 3). In this case, the coefficient on the lagged percentage price change is significant on the first sub-period but not in the second. In other words, a knowledge of how GNMA prices moved last week no longer contains useful information as to how they will move this week. All new information affecting GNMA prices is rapidly incorporated into the current market price rather than absorbed by the market slowly over several weeks. In the language of capital-market theory, the GNMA market has become more "efficient" since futures trading began.[30]

Table 2
Time Series Analysis of Spot GNMA Prices

Sample Period	Constant	GNMA (−1)	GNMA (−2)	Standard Error	Durbin-Watson
May 30, 1973-	3.48	1.20	−0.238	0.707	2.05
December 28, 1977	(2.44)	(18.5)	(−3.70)		
May 30, 1973-	4.06	1.22	−0.261	0.844	2.05
October 15, 1975	(1.98)	(13.1)	(−2.84)		
October 22, 1975-	6.26	1.07	−0.139	0.526	2.06
December 28, 1977	(2.24)	(11.6)	(−1.54)		

(Numbers in parentheses are t-statistics.)

Table 3
Time Series Analysis of Percentage Weekly Change in GNMA Prices

Sample Period	Constant	Lagged Percentage Change in Price	Standard Error	Durbin-Watson
May 30, 1973-	−0.00016	0.224	0.0075	2.04
December 28, 1977	(−0.32)	(3.46)		
May 30, 1973-	−0.00053	0.246	0.0091	2.03
October 15, 1975	(−0.61)	(2.66)		
October 22, 1975-	0.00024	0.153	0.0056	2.04
December 28, 1977	(0.47)	(1.66)		

(Numbers in parentheses are t-statistics.)

IV. Summary and Conclusions

The empirical results presented in this paper all suggest that the GNMA spot market has improved its performance in the period since futures trading began in those securities. The spot market has become more efficient in processing new information; it has shown less purely random price variability; and it has become more closely integrated with the rest of the bond market. It is impossible to say with certainty how responsible futures trading has been for any of these beneficial developments. But it seems clear that futures trading in GNMA certificates has not had a destabilizing effect on spot market prices.

The significance of this conclusion extends beyond the GNMA market. Financial futures markets are still in their infancy. Proposals for still more of them are constantly being made. The results of this study of GNMA futures suggests that we have nothing to fear and potentially much to gain from the further development of these markets.

FOOTNOTES

1. See, for example, the discussion by B.A. Goss and B.S. Yamey in their introductory essay in **The Economics of Futures Trading,** ed. Goss and Yamey (New York: John Wiley and Sons, 1976), pp. 29-32.
2. "Stability in a Swinging Market," **Business Week** (August 8, 1977), p. 70.
3. **Federal Reserve Bulletin** (February 1978), p.A41.
4. "A Fever of Speculation Afflicts Ginnie Mae," **Business Week** (July 18, 1977), p. 28.
5. "Interest Rate Futures Gain Popularity," **Wall Street Journal** (February 2, 1978), p. 1.
6. This section draws heavily on the article by Richard L. Sandor, "Trading Mortgage Interest Rate Futures," **Federal Home Loan Bank Board Journal** (September 1975), pp. 2-9.
7. Futures markets exist for other reasons than merely to accomodate "hedging" in the narrow sense of risk avoidance in which that term is commonly used. See Holbrook Working, "Economic Functions of Futures Markets," in **Futures Trading in Livestock—Origins and Concepts,** ed. Henry Bakken (Madison, Wisconsin: Mimir Publications, Inc., 1970), pp. 29-41. Also Roger W. Gray, **The Feasibility of Organized Futures Trading in Residential Mortgages,** FHLMC Monograph No. 3 (November 1974), p. 6.
8. John R. Hicks, **Value and Capital** (London: Clarendon Press, 1946), pp. 144-147; Paul H. Cootner, "Common Elements in Futures Markets for Commodities and Bonds," **American Economic Review** (May 1961), pp. 173-183.
9. Gray (p. 13) notes some offsetting advantages of mortgages over commodities, such as lack of storage and transportation problems.
10. Winfield A. Boileau, "GNMA Pass Through," in **Investment Opportunities, The GNMA Story,** Mortgage Bankers Association (1977), pp. 5-9.
11. For a general discussion of governmental programs to aid the secondary mortgage market, see Peggy Brockschmidt, "The Secondary Market for Home Mortgages." Federal Reserve Bank of Kansas City **Monthly Review** (September-October 1977), pp. 11-20.
12. The forward market is described in Thomas C. Miller, "Growth, Acceptance to Improve Liquidity of GNMA Security," **Investment Opportunities, The GNMA Story,** Mortgage Bankers Association (1977), pp. 19-22.
13. Lester Telser and Harlow Higinbotham, "Organized Futures Markets: Costs and Benefits," **Journal of Political Economy** (October 1977), pp. 969-1000. Also, Gray, p. 10.
14. These figures have been taken from various issues of the **Interest Rate Futures Newsletter** of the Chicago Board of Trade.
15. For example, Neil A, Stevens, "A Mortgage Futures Market," Federal Reserve Bank of St. Louis **Review** (April 1976), pp. 12-19.
16. John Stuart Mill, **Principles of Political Economy** (London, 1848), Book 4, Chapter 2, Section 4, as quoted in Goss and Yamey, p. 30.
17. "Stability in a Swinging Market," **Business Week** (August 8, 1977), p. 71.
18. Working, p. 47.
19. Milton Friedman, "The Case for Flexible Exchange Rates," **Essays in Positive Economics** (Chicago: University of Chicago Press, 1953) p. 175.

20. Friedman, p. 175.
21. Nicholas Kaldor, "Speculation and Economic Stability," **Review of Economic Studies** (1939-40), pp. 2-3. An alternative model involving two groups of speculators has been suggested by Fred Glahe, "Professional and Nonprofessional Speculation, Profitability, and Stability," **Southern Economic Journal** (July 1966), pp. 43-48.
22. See the discussion (and references) in Robert M. Stern, **The Balance of Payments** (Chicago: Aldine Publishing, 1973), pp.77-89. Also, Jorg Schimmler, "Speculation, Profitability, and Price Stability," **Review of Economics and Statistics** (February 1973), pp. 110-114.
23. Abba Lerner, quoted in Goss and Yamey, p. 32.
24. All of the regressions presented in this article were also run for subsamples which omitted the months immediately surrounding the start of futures trading. Similarly, they were run using different proxies for the market index. The qualitative results were not different for any of these alternatives.
25. For a full discussion of this approach to measuring an asset's risk, see Michael C. Jensen, "The Foundations and Current State of Capital Market Theory" in **Studies in the Theory of Capital Markets,** ed. Jensen (New York: Praeger, 1972), pp. 3-43.
26. The F-value calculated for these regressions is 0.085, which is well below the critical value of 3.04. See Jan Kmenta, **Elements of Econometrics** (New York: Macmillan, 1971), p. 373.
27. The F-statistic for a reduction in the standard error across the two samples is the ratio of the two sums of squared residuals, each divided by the respective degrees of freedom. The calculated F-value is 2.39, compared to the critical value of 1.59.
28. George E. P. Box and Gwilym M. Jenkins, **Times Series Analysis** (San Francisco: Holden-Day, 1970).
29. The calculated F-value for the test of equality of coefficients is 2.31, which is below the critical value of 2.65. The calculated value for the test of reduction in standard error is 2.57, which is greater than the critical value of 1.59.
30. See Eugene F. Fama, "Efficient Capital Markets: A Review of Theory and Empirical Work," **Journal of Finance,** (May 1970). Although the regressions presented in Table III show that past movements in GNMA prices formerly contained information useful for predicting future movements in those prices, it is not necessarily the case that profitable arbitrage possibilities existed during the first sub-period. Transactions costs may have been too high for investors to exploit the predictive content of past price movements. The futures market, by reducing the costs of taking a short position, may have allowed investors to exploit the information in past prices. This interpretation of the results in Table 3 was suggested by Kurt Dew.

Public and Private Sector Information in Agricultural Commodity Markets

Michael Gorham*

When we examine the decision-making of participants in any market, we see that most participants rely upon some source or sources of information to enhance the value of their decisions. We also notice that relevant information in many markets is available from both the public and the private sector. The public/private information mix varies widely over markets. In some, such as the markets for air conditioners, shoes, calculators and pre-EPA automobiles, there is virtually no public-sector information. In others, such as the markets for labor, financial instruments and agricultural commodities, the public sector plays a very large role.

The purpose of this paper is to explore the relationship between public- and private-market information, with particular emphasis on a specific market with a large component of public-sector information—the market for agricultural commodities. First, we show how public information both destroys and creates opportunities for providers of private-sector information. We then measure the private sector's response to these new opportunites in the case of three major agricultural commodities with highly-developed spot and futures markets. Our analysis indicates that private-information sources correctly forecast public-sector announcements for soybeans, but do not do so for corn and wheat.

I. Relationship Between Public and Private Sector Information

In order to discuss the interaction of public and private information, it is useful to construct a model of an information sector. In doing so, however, it is not necessary that all the real-world circumstances be exactly duplicated. Basically, the model involves the development of a commodity market, the emergence of private firms supplying information to market participants, and the entry of public-sector information providers—due to the public sector's belief that an inadequate supply of information is available from the private sector. Finally, the model includes a readjustment by private firms to the new presence of the public sector.

Private-sector entry

A market for a particular commodity or commodity group emerges at some point in time. In developing countries, this may happen when a commodity emerges from the traditional world of subsistence agriculture and is bought and sold in the market. In developed economies, this may happen when a new commodity or service is created, such as microwave ovens, calculators, stock options or kiwi fruit.

As a market emerges, so too do information providers. In some cases, market participants may conduct their own information search through discussions with other market participants; thus the information providers and the information users become one and the same. This would tend to be true of very small markets. In other cases, a distinct set of private-sector information providers may arise. Some may simply be existing firms which expand to cover a new market, while others may be new firms. In either case, resources are organized to provide information to a new market when it is profitable to do so. Private-sector information expands until the cost of providing the last unit of information is just equal to its price—or value, when market participants generate their own information.

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Public-sector entry

This equilibrium amount of private information is provided until the public sector makes its entry. If the public sector is assumed to aim at maximizing social welfare, specifically with regard to the use of information as a public good, then it would be likely to consider available information inadequate whenever the private sector is left to do the job on its own. The public sector thus would "decide" to undertake the task of creating the appropriate information.[1]

However, public servants may be just as interested in their own survival as in social welfare. In a democracy, high-level public servants are either elected by the populace or serve at the pleasure of those who are so elected. If a large voting bloc wants the public sector to provide information to some particular market, public officials would be likely to pay attention because of their own interest in re-election. Their willingness to grant such requests would depend upon the voting strength (or campaign support) of the interests affected, but also upon their own ability to justify to others the social subsidy involved in the public provision of the information in question. In the case of agriculture, the farm sector's political power could be expected to generate demands for publicly-provided information on commodity markets, with this situation being justified to the rest of society on the grounds of its contribution to a stable supply of food at stable prices.

One caveat is in order. Not all participants in all markets would benefit from the public provision of market information. Some participants who benefit from a less-than-competitive market might suffer if broadly available information made that market more competitive. Where freely-supplied market information provides a positive value to market participants, those participants would have an incentive to ask for it. But where the government obtains market information through surveys, the value of the information would have to exceed any inconvenience costs before market participants would have any incentive to request it.

Private-sector response

When government provides market information, it disrupts the equilibrium in the production of private information. To the extent that the free (or low-cost) government information substitutes for existing private-sector information, private providers may be forced to change their product or to leave the business entirely. But at the same time, new opportunities can arise from these private firms. They can provide analysis and prescription—in other words, translate government statistics into specific market advice in the form of market letters. They can also sell information predicting what the next package of government information will say. Good predictions are valuable to people who want to profit by taking positions in advance of any price change induced by the next release of government information.

This last stage could be characterized as a market with a mature information sector—one which has reached a second stage of equilibrium incorporating both private- and public-sector information flows. With the completion of the external shock from the public sector, any new adjustments will probably be relatively minor. There will always be commodity-market changes which induce further changes in its associated information sector. There will also be technological changes in the information industry itself. These may arise from developments in theoretical or applied statistics, such as those which led agricultural officials to adopt new sampling techniques during the early 1960's or from innovations in engineering, such as the remote sensing devices which allow satellites to "photograph" the midwestern corn crop or the Brazilian coffee crop.

II. Information in the Market for Agricultural Commodities

The public sector probably accounts for a greater share of total market information in agriculture than in any other market except finance. And despite continuing minor changes, the information sector in agriculture can appropriately be characterized as mature. The public sector began providing information to these markets over a century ago, and the private sector has generally completed its adjustment to this government role. At this point, it would be useful to consider the institutional background to the information sector associated with these commodity markets.

Public-sector information

The U.S. Department of Agriculture (USDA) provides virtually all the public-sector information relevant to the nation's agricultural markets. (However, the Department of Commerce and the Federal Reserve provide information on related economic conditions, and farm officials in individual states generate data on local agricultural markets). The USDA publishes production, price and other data for all major (and many minor) crop and livestock products. Most of this information is available free of charge, and it is widely used by farmers, merchants, and other market participants.

One of the most useful USDA series is the monthly Crop Production Report, which contains harvest forecasts for a number of major crops. Early in the year, farmers are asked how much acreage they intend to plant to each crop, and those planting intentions are compiled for each major crop by state. After the planting season, Department representatives count the plants growing in a systematic sample of all U.S. farms. Because of the comprehensiveness and predictive accuracy of these surveys, USDA announcements of expected crop production are generally taken as scripture by market participants.

Private-sector information

The private sector tends to complement rather than substitute for the public sector, reflecting the fact that the latter already provides a vast amount of free and high-quality information. In the private sector, it is useful to distinguish between the information that market participants generate for sale to others in the market. Some firms generate information in the form of market letters and market-information services, but others— such as large grain companies, food-processing firms, and food-brokerage firms— generate substantial amounts of internal information as a means of identifying emerging market opportunities as quickly as possible. Because of the difficulty of measuring this type of market information, the tests performed in the next section of this article must be indirect rather than direct.

Private-sector firms, again, may complement the USDA both in the collection and the analysis of raw data. There might appear to be little opportunity for private firms in the area of data collection since the USDA collects data on practically every variable of interest to market participants, but these firms still play an important role by filling a time gap. USDA information is published at regular intervals—weekly, monthly, quarterly, or annually—but important developments often occur between reporting dates and thereby affect the profit prospects of market participants. Some firms develop interim estimates by conducting limited field surveys, but most develop these estimates by evaluating the effects of weather, disease or pest developments on the most recent USDA estimates of crop production.

Private firms similarly play an important role by filling an analysis gap. While the USDA provides some useful analysis in its Situation Reports, it does not usually predict price movements, nor does it provide market participants with advice on the positions they should take in the market. This type of analysis gap is filled by a number of market letters and services, each of which is generally aimed at a different audience of farmers, merchants, or speculators.

III. Measuring the Performance of the Private Information Sector

The agricultural-information sector is mature in the sense that it has already incorporated both a public-sector entry and a private-sector response. But how successful has the private sector been in filling the analysis gap and the time gap that remain after the public sector has done its job? We cannot answer in the case of the analysis gap, which is not amenable to quantitative testing, but we can make an estimate in the case of the time gap. Fortunately, we can do so without inspecting private-firms' actual predictions. This is doubly fortunate because private-sector subscriber information is often difficult or costly to acquire—and frequently difficult to evaluate because of being presented in qualitative rather than quantitative terms—while much other private forecast information is simply impossible to acquire because of being prepared only for confidential internal documents.

Nature of test

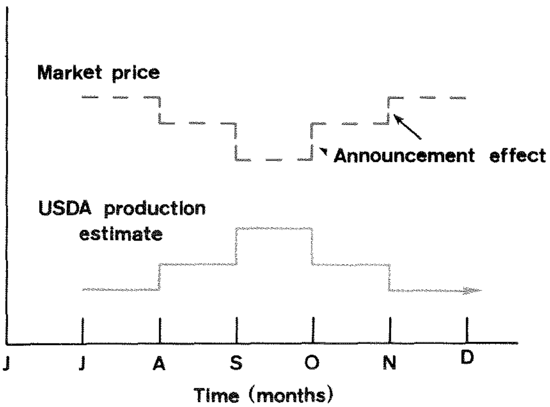
The test consists of examining the effects of USDA output forecasts on specific commodity prices. If USDA announcements are fully anticipated by market participants, they should not affect market prices, but if they are surprises, they should cause prices to jump one way or the other. Thus, from observing the movement of market prices in response to USDA announcements, we can infer how well the private-information sector forecasts those announcements. (Chart 1).

The USDA typically makes monthly forecasts of the coming harvest of wheat, corn and soybeans from midsummer through November each year. County surveys of crop conditions are conducted around the first of the month, and are then sent to Washington and kept in a double-locked box until the compilation of the official estimates around the tenth of the month. On that day, compilers work behind locked and guarded doors until the state and national totals are tabulated and inspected by a representative of the Secretary of Agriculture. That individual takes the approved report directly to the USDA press room, where it is released immediately. In other words, utmost secrecy surrounds the preparation of production estimates for crops which are traded heavily in commodity markets.

If the USDA were the only source of information, a unique price could be associated with any given crop-production forecast, and prices would change only after a monthly announcement changed the previous forecast. In other words, the world might look something like Chart 1. But when other reliable information is available the

Chart 1

USDA AS SOLE SOURCE OF CROP INFORMATION



market-price path will appear more jagged during the month and the announcement effect on prices will be more moderate. In the extreme case, private-sector information may become so well developed that the USDA will never offer any surprises and the announcement effect on prices will be zero.

In order to estimate this announcement effect, we examine the monthly production forecasts and associated market prices for three commodities (corn, wheat and soybeans) for the 1970-77 period. The announcement effect is represented by the coefficient "b" in the following basic equation:

$$\%\Delta P = a + b\%\Delta Q \qquad (1)$$

where $\%\Delta Q$ is the percentage change between the current month and the previous month in the USDA harvest forecast, and $\%\Delta P$ is the percentage change in the market place between the day of and the day following the announcement. (Price is measured by the closing futures' price of the post-harvest contract, which is December for wheat and corn and January for soybeans.) Since the USDA announcement is always made at 3 p.m. EST, after the close of all spot and futures markets, this information should be fully captured by the change in the price between the close of the market on the announcement day and the same time on the following day. Also, to take account of the ceilings imposed on daily futures' price movements, the terminal price used in the $\%\Delta P$ figure is the closing price on the first post-announcement day on which the limit was not reached.

Some asymmetry is involved in using daily price changes on one side of the equation and monthly quantity changes on the other. However, an example will demonstrate the appropriateness of our test. Assume that a wheat-crop forecast is made on the 10th of July, and that the market accepts this as the best available at that time. As the month progresses and rainfall becomes lighter than expected, private-information providers will adjust the July USDA forecast downward. To the extent that this downward adjustment is off the mark and the market is surprised by the new USDA forecast of August 10, the surprise will show up only in the August 11 price change. Thus, since we are simply trying to estimate the degree to which the market is surprised by the USDA forecast adjustment, this test is appropriate. If, on the other hand, we were trying to estimate an elasticity of demand, we would need to use the same time period for both price and quantity, and the test used here would not be appropriate.

A recent unpublished paper by Pearson and Houck[2] uses a non-parametric chi-square test to examine the hypothesis of an inverse relationship between USDA forecast adjustments and associated market-price changes. For the 1963-75 period, they found that forecast changes and market prices moved in opposite directions for corn, soybeans, and spring wheat, but not for winter wheat. The current paper extends the Pearson and Houck tests by 1) using regression analysis for estimating the magnitude of the announcement effect, 2) expanding the sample period from 12 to 28 years, and 3) testing for changes in the announcement effect through the crop season and over time.

Announcement effect?

We obtain the following results from estimating Equation 1 (t values in parenthesis):

$$\%\Delta P_S = -.632 - .004\%\ \text{Soybeans} \qquad R^2 = .000$$
$$(2.43)\quad (0.05) \qquad DW = 1.97$$
$$SER = 2.36$$
$$n = 84$$

$$\%\Delta P_W = .028 - .202\%\ \text{Wheat} \qquad R^2 = .029$$
$$(0.10)\quad (1.56) \qquad DW = 2.07$$
$$SER = 2.48$$
$$n = 84$$

$$\%\Delta P_C = .078 - .236\%\ \text{Corn} \qquad R^2 = .079$$
$$(0.31)\quad (3.01) \qquad DW = 1.68$$
$$SER = 2.60$$
$$n = 107$$

While the explanatory value of the equations is quite low, all of the coefficients carry the expected sign, which implies that price moves in the opposite direction from quantity. However, the relationship is highly significant only for corn, while it is weakly significant for wheat and essentially zero for soybeans. This suggests that the private market does a very good job anticipating changes in the soybean forecast, a somewhat poorer job anticipating changes in the wheat harvest and a considerably poorer job in anticipating changes in the corn harvest. Note that while the magnitude of the announcement effect is roughly the same for wheat and corn, the effect for corn is much more statistically significant.[3]

Much of this difference can be explained by technical differences among crops. Soybeans are a very hardy crop, so that month-to-month changes in temperature and rainfall affect yields to a relatively minor extent. Corn and, to a lesser extent, wheat yields are much more affected by environmental changes. In fact, the variability of soybean yields is roughly only half that of corn or wheat (Table 1). The ranking of the crops by variability of yield parallels their ranking by the private sector's output-forecasting performance, which suggests that the technical difficulty of the task is the primary factor determining the private sector's ability to forecast changes in USDA estimates.

Table 1
Per-Acre Crop Yields, 1966-76[a)]
(Bushels per Acre)

	Mean	Standard Deviation	Coefficient of Variation
Soybeans	25.52	1.83	.072
Wheat	27.94	3.36	.120
Corn	75.12	12.71	.169

a) Yield data taken from USDA, *Agricultural Statistics 1977*

Variation over crop season

As the crop season progresses, the uncertainty associated with crop estimates decreases. Crop-production estimates are based upon: 1) an estimate of planted acreage, and 2) an estimate of yield per acre. While good acreage estimates can be obtained early in the season, initial yield estimates are subject to change during the course of the season. As the season progresses, yield estimates involve fewer assumptions and therefore become less uncertain. Consequently, both the public and private sectors should do a better forecasting job as the season progresses. Indeed, throughout the past 28 years, the accuracy of the USDA forecast improved and the variation in the forecast error fell as the season advanced. (Table 2).

Table 2
Accuracy of and Variation in USDA Monthly Forecast, 1950–77

	Forecast/post-harvest estimate				
	July	August	Sept.	Oct.	Nov.
Soybeans	—	.990	.996	.997	.997
Wheat	.993	.996	.999	.999	.999
Corn	—	1.031	1.032	1.035	1.040
	Variation in Forecast Error[a]				
Soybeans	—	.080	.043	.034	.027
Wheat	.044	.023	.010	.016	.016
Corn	—	.084	.077	.076	.077

a) Measure of variation $= \sqrt{\frac{1}{m} \sum_{i=1}^{m} \left(\frac{\text{forecast}_i - \text{final}}{\text{final}} \right)^2}$

While summary statistics similar to those in Table 2 cannot be constructed for private-sector forecasts (for reasons explained above), the private sector's improvement through the crop season can be measured in an indirect fashion. If this sector improves its forecast at roughly the same rate as the public sector we would expect to find no systemetic change in the announcement effect over the crop season. If, on the other hand, it lags behind the public sector's performance, we would expect to find an increasingly significant announcement effect over the crop season.

To test this hypothesis, we estimated Equation 1 separately for each monthly change. For example, the announcement effect for the July/August change in the corn forecast, estimated with the 28 annual observations, can be seen in the upper right hand corner of Table 3. Altogether, no consistent increase or decrease in the announcement effect is apparent over the crop season. This suggests that the private sector does indeed improve its forecasts at roughly the same rate as the private sector. However, since forecast improvements over the crop season are due almost exclusively to an easier forecasting environment, it might be expected that all forecasters would find themselves improving at about the same rate.

Table 3
Announcement Effect As Crop Season Progresses[a]

Month of Change	Soybeans	Wheat	Corn
July/Aug.	c	−.218 (1.18)[b]	−.061 (0.99)
Aug./Sept.	−.011 (0.12)	−.186 (0.78)	−.443 (2.16)
Sept./Oct.	−.051 (0.25)	−.935 (0.77)	+.028 (0.18)
Oct./Nov.	−.008 (0.03)	d	−.550 (2.85)

a) Announcement effects are estimates of "b" in Equation 1, calculated for each crop and for each monthly change. Each estimate is based upon 28 observations for the 28 years of the sample.

b) t-values in parentheses

c) No soybean-crop estimate prepared for July.

d) October/November changes were too small to use for estimation.

Variation over time

The USDA has taken a number of steps to improve the accuracy of its forecasts, and these measures have led to a gradually improved forecast ever since 1929.[4] Even within the shorter 1950 to 1977 period under consideration in this paper, the accuracy of USDA forecasts has improved considerably, as is evident from the shrinking variation in the forecast error displayed in Table 4. The only exception is a decline in the forecasting accuracy for soybeans as we move from the late 1960's into the commodity-turbulent early 1970's.

Table 4
Variation in the USDA Forecast Error Through Time, 1950-77[a]

	1950-56	1957-63	1964-70	1971-77
Soybeans	.076	.037	.033	.042
Wheat	.037	.025	.024	.022
Corn	.137	.075	.054	.043

a) Measure of variation used here is the same as that in Table 2.

But has the private sector kept pace with these public-sector improvements? In a test similar to the one above, Equation 1 was estimated for each of four 7-year periods, with the results reported in Table 5. With only a single exception, the announcement effect grew increasingly larger and more significant over time—that is, market participants became increasingly surprised over time. This suggests that the private sector lagged behind the public sector in improving its forecast.

This might have been expected. Unlike the forecast improvement over the crop season, which is attributable to environmental changes, improvements over time are generally attributable to actions taken by the forecasting agent itself. Because some improvements may be too costly to be adopted by private firms (since they may not stimulate a commensurate rise in revenues), the public sector adoption of such improvements would tend to enhance its forecast accuracy relative to the private sector. Examples might be a move to larger sampling frames or more intensive physical counts within each frame. Thus, due to the profitability constraint in the private sector, a well-endowed public sector agency like the USDA might be expected to improve its forcasts at a more rapid rate than the private sector, thus generating larger announcement effects over time. (A more formal and technical presentation of this interpretation can be found in the Appendix.)

Table 5
Announcement Effect Over Time[a]

Period	Soybeans	Wheat	Corn
1950-56	.021 (0.45)	.003 (0.08)[b]	−.017 (0.31)
1957-63	−.134 (1.34)	−.016 (0.31)	−.147 (1.45)
1964-70	−.315 (2.31)	−.198 (1.27)	−.229 (2.14)
1971-77	.214 (0.63)	−.972 (1.63)	−.918 (2.60)

a) Announcement effects are estimates of "b" in Equation 1 for each crop, for each of four time periods. Corn equations are based upon 35 observations (5 months x 7 years); wheat and soybean equations are based upon 28 observations (4 months x 7 years).

b) t-values in parenthesis

IV. Conclusion

This paper was designed to explore the relationship between the provision of public and private information to participants in commodity markets. We emphasized particularly the market for agricultural commodities, since this is a market with a large component of public-sector information.

Whenever public information is considered reliable, its release would be expected to have a significant impact on the market. However, market participants have an obvious incentive to predict such public announcements, since this is equivalent to predicting a movement in prices. In a mature information sector, private information providers would become fairly adept at making such predictions, so that we would expect to find a fairly weak public-announcement effect. In our test, however, we found that the private information sector did a good job of prediction only for soybeans. Corn and, to a lesser extent, wheat still have significant announcement effects.

For technical reasons, public-sector information generally improves in quality over the crop season—and the same appears to be true for private-sector performance. However, over time, public-sector information has improved in quality, whereas the private sector's forecasting ability has lagged behind.

This should not be too surprising. The public sector, unlike the private sector, is not constrained by considerations of profitability when adopting improved methods of forecasting or expanding its survey activities—although of course it is subject to certain budget constraints. Thus, in response to constituents and other pressures, the USDA has been able to improve its forecasting ability more rapidly than has the private sector.

APPENDIX

The notion that an increasing announcement effect suggests that the private sector lags the public sector in increasing its forecast accuracy has some intuitive appeal. However, a more formal demonstration of the conditions under which diverging forecast accuracy leads to increased announcement effects would make such a notion more plausible.

Let G and P represent the forecast error of the government and private sector respectively. Furthermore, let the government error be written as a function of both the private sector error (to the extent that both sectors make the same types of mistakes) and its own unique source of error, E, such that:

$$1)\quad G = aP + E$$

where $a > 0$ to reflect the fact that both private and public tend to make errors in the same direction, and both E and P have zero mean and some positive variance, σ_E^2 and σ_P^2 respectively. Assume further that the covariance between P and E is zero and that a is independent of both σ_E^2 and σ_P^2. Now, the variance of the government error can be written as a function of the variance of the private error and the independent government error

$$2)\quad \sigma_G^2 = a^2\sigma_P^2 + \sigma_E^2$$

Let us take the case where the errors initially have the same variance and then the variance of the government error falls, while the variance of the private error remains unchanged. There are two ways in which the variance of the government error can decline according to equation 2. Either "a" could fall which would mean that the government began to rely less on the methods or data it shared with the private sector, or σ_E^2 could fall because of increased public sector reliance on better techniques or data not available to the private sector.

The announcement effect could either increase or decrease depending upon which of these two factors, a or σ_E^2, was responsible for the accuracy of the government forecast. Since the size of the announcement effect depends upon the expected difference between the two errors, let us write the square of that expected difference as

$$3)\quad E(P-G)^2 = (a-1)^2\sigma_P^2 + \sigma_E^2$$

Clearly, if the government increases its accuracy by reducing the variance of the error unique to the government, i.e., σ_E^2, then the expected difference expressed in equation 3 will also fall and the announcement effect will decrease. If, on the other hand, government accuracy increases because it improves on a technique used by both sectors (while the private sector does not make the improvement), then "a" falls. Note that $0 < a < 1$ since we assumed (1) that government and private errors were positively correlated which implies $a > 0$ and (2) that initially $\sigma_P^2 = \sigma_G^2$, which from equation 2 implies that $a < 1$. Now, as a positive "a" approaches zero, the expected difference in equation 3 grows and, thus, the announcement effect grows larger.

So, it is only an increase in government accuracy via a fall in "a" that is consistent with our interpretation in this paper. The question then becomes whether the actual source of increased USDA accuracy has been a fall in σ_E^2 or a. For one thing, private forecasters can sell their forecasts partly on the basis that they are good forecasts of yet-to-be-announced USDA forecasts, thus allowing subscribers to take advantageous market positions. This creates an incentive for private forecasters to behave in a manner that keeps "a" as close to 1 and E as close to zero as possible (in equation 1). To the extent that they are successful in this and that there is little E and a lot of "a" for the public sector to reduce, most of the reduction in the variance of the public sector forecast would likely come from reductions in a. Futhermore, the government forecasts are based upon surveys of farms, while the private sector forecasts are based both upon farm surveys and the integration of secondary information on weather conditions, random media coverage of the farm sector and so on. To the extent that USDA expands the size or quality of its farm surveys beyond that allowed by profitability considerations in the private sector, this represents a fall in "a" and an increased announcement effect. This is probably more typical of what has taken place over the past several decades. (Note: This treatment was suggested by Patrick Weber.)

1. A **public good** is one whose cost of production is unaffected by the number of people who consume it. This is to be distinguished from a **collective good,** which (once produced) is automatically consumed by all. (Public safety is a collective good.) Information, per se, is a pure public good, since the cost of creating it is the same whether it is used by one or by a million people. (Note that while the message is a public good, the medium—book, pamphlet or magazine—is a private good.) The problem with a public good is that the private sector will not price it at the marginal cost of production—which is zero since adding a new consumer costs nothing—but will rather charge some price which will cover fixed costs and allow a profit. It is generally recognized that this is not optimal, because (once produced) the information can be provided to additional people—i.e. social welfare can be increased—at no additional cost. While this suggests that government intervention **may** make society better off, it is by no means clear that it would.

The private sector can come fairly close to providing the optimal amount of information if it can charge each consumer a price equal to the value of the information to him or, more realistically, if the cost of creating the information becomes very small relative to the cost of disseminating it. In the latter case, the portion of the price attributable to the public good (the message) approaches the optimal level of zero, while the bulk of the price charged to the consumer is the price of the private good (the medium). In the case of paperback books, information costs are low relative to dissemination costs, and thus the private sector may be providing close to the optimal amount of information; in the case of the National Income Accounts, production costs are so great that the private sector would probably provide considerably less than an optimal amount. Information on agricultural markets probably lies somewhere between these two extremes, but closer to the latter.

The classic article on the optimal level of a public good is Paul Samuelson, "The Pure Theory of Public Expenditure", **Review of Economic Studies** (November 1954). A recent merging of the public-goods and economics-of-information literature can be found in Bruce Owen, Jack Beebe and Willard Manning, **Television Economics** (Lexington, Mass: Lexington Books, 1974).

2. Daniel Pearson and James P. Houck, "Price Impacts of SRS Crop Production Reports: Corn, Soybeans, and Wheat," unpublished manuscript, Department of Agriculture and Applied Economics, University of Minnesota, April 1977.

3. The price effect of a change in the harvest forecast should be rather sensitive to the amount of the commodity currently in storage. The new harvest does not usually make up the total supply, but simply adds to that supply—and price is determined by the intersection of demand and total supply. Since stock levels changed considerably over the sample period, it seemed appropriate to control for these changes. Thus Equation 1 was modified such that $\%\Delta Q$ refers to the change in total supply, where total supply equals July 1 stocks plus the harvest forecast. As might be expected, the size and significance of the coefficients and the fit of the equations improve modestly, though the announced effect for soybeans remains essentially zero. The new estimated equations are:

$$\%\Delta P_S = .629 - .013\ \%\Delta\text{Total Soy} \quad R^2 = .003$$
$$(2.42)\ (0.15)$$

$$\%\Delta P_W = .020 - .356\ \%\Delta\text{Total Wheat} \quad R^2 = .040$$
$$(0.07\ (1.84)$$

$$\%\Delta P_C = .059 - .357\ \%\Delta\text{Total Corn} \quad R^2 = .086$$
$$(0.24)\ (3.16)$$

4. A moderate improvement in USDA forecast accuracy over the 1929-1970 period was discovered using different techniques than those in Table 4 by G. Gunnelson, W.D. Dobson, and S. Pamperin, "Analysis of the Accuracy of USDA Forecasts," **American Journal of Agricultural Economics** (November 1972).

Practical Monetarism and the Stock Market

Kurt Dew*

Is today's monetary policy more effective than the monetary policy of earlier decades? Since the 1960's, dramatic changes have occurred in both monetary policy procedures and the amount of information provided by the Federal Reserve to Congress and the public. Still, the language of both Fed critics and advocates is sometimes reminiscent of an earlier time. The new procedures, coupled with the not-so-new debate over policy options, raise a question: are the procedural changes only differences in style, or does monetary policy now affect the economy in a substantially different way than it did in the 1960's?

The changes that led to the present policymaking approach began in 1966, when the Fed began "paying attention to the monetary aggregates." These procedures developed gradually between 1966 and 1975, and the interested reader may find detailed accounts of the development in several sources [c.f. (2), (8), (11)]. Finally, in March of 1975 Congress required the Federal Reserve to "... consult with Congress ... about the Board of Governors' and the Federal Open Market Committee's objectives about the rate of growth or diminution of monetary and credit aggregates in the upcoming twelve months." (9) This Congressional Resolution solidified the Fed's commitment to an approach that assigned great importance to the behavior of various measures of the quantity of money. The Federal Reserve's new procedures have come to be called "Practical Monetarism" by the financial press.

Was the monetary policy of the early '60's, when the Fed did not pay explicit attention to money, really different in economic impact from the practical monetarism of post-1975, or were the changes primarily cosmetic? This question may be subdivided:

1. Does the Fed actually respond to the behavior of the money stock in a way it did not in the 1960's?
2. If the Fed does respond differently, has the change altered the structure of the national economy in any significant way?

This article will utilize the developing theory of efficient markets to show that the Fed's response to growth in M_1 has changed, and as a result, the economic impact of a temporary deviation of M_1 from trend has actually been reversed. Section I shows that the public record is inconclusive about the Fed's attempts to control money. Public pronouncements of Federal Reserve officials suggest that the monetary aggregates are more important in the policy process now than before, but there is no explicit evidence that the behavior of the monetary aggregates changes policy decisions. Furthermore, there is no shortage of criticism of the Federal Reserve on the grounds that the Fed continues to pay insufficient attention to money.

In Section II, the case is made that the Fed today raises interest rates in response to undesirably rapid money growth, whereas it did not do so in the 1960's. This change in response is revealed indirectly, through an analysis of the stock market's response to the money supply. The conclusion is based on the evidence that the stock market today (unlike the 1960's) responds negatively to an increase in the money supply—and the proposition that the stock market is an efficient forecaster of the future economic impact of a change in the money supply, which impact in turn depends on the Federal Reserve's policy reaction.

Section III argues that the new emphasis on the monetary aggregates has in fact altered the structure of the economy, and that most econometric models of the monetary-transmission process are mis-specified as a result. This section raises questions about a naive interpretation of the portfolio-adjustment theory of the transmission of monetary policy—namely, that an excess demand or supply of money *precedes* changes in

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long-term interest rates and equity values, which changes in turn influence levels of real economic activity. The empirical work presented here indicates that stock prices and interest rates primarily reflect anticipated trend rates of money growth. Thus, according to a more accurate interpretation of portfolio theory, past rates of money growth affect current real economic activity only if they affect forecasts of future money growth.

I. Recent History of Monetary Policy

By all accounts, the most important and most controversial change in monetary policymaking in the last several decades has been the increasing importance attributed to various measures of money—in particular, the narrowly-defined M_1 measure (currency and demand deposits) and the broader M_2 measure (currency plus all bank deposits except large negotiable CD's). According to the minutes of the Federal Open Market Committee (FOMC), that key policymaking committee clearly has paid greater *attention* to the behavior of M_1 over time. The first such expression of interest occurred in 1966, when a "proviso" clause was first included in the Directive, the document containing the monthly instructions from the FOMC to its operating arm, the System Open Market Account (SOMA). An example of a Directive with a proviso clause was the December 1967 Directive (4):

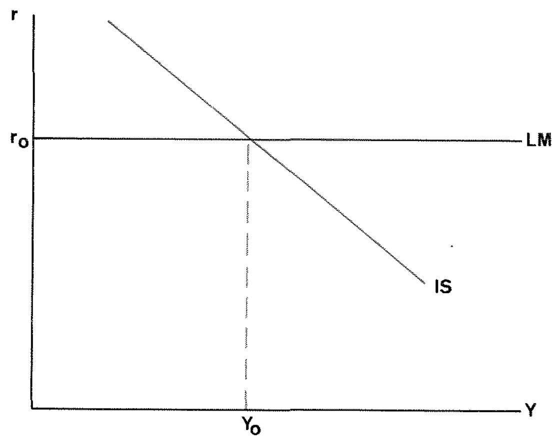
> "..., System open market operations until the next meeting of the Committee shall be conducted with a view to moving slightly beyond the firmer conditions that have developed in money markets ... *provided*, however, that operations shall be modified as needed to moderate any apparently significant deviations of bank credit from current expectations or any unusual liquidity pressures. (emphasis added)"

The proviso clause was the first explicit FOMC recognition of the need to pay attention to unanticipated behavior of the money and credit aggregates during the periods between meetings. But even with that clause, it remained unclear exactly how the information on money included in the Directive would feed into actions of the SOMA and its Trading Desk. For several years, various Directives mentioned growth in money and credit, but did not give the Desk instructions about what to do should the aggregates go off course.

As a result of historical experience, such as the undesirably rapid growth of money supply in the last half of 1968, the FOMC came to place more emphasis on the aggregates. The February 1970 Directive, for example, put the financial community on notice that moderate growth in M_1 and the other aggregates was an important FOMC objective. However, the role of money in the new procedure remained ambiguous. Thus, in his testimony before the Congressional Joint Economic Committee on July 23, 1970, Chairman Burns emphasized that changes in money growth sometimes would have little effect on subsequent FOMC decisions.

> "An impression seems to have prevailed in some quarters that the Federal Reserve had decided to pursue fixed target rates of growth in the monetary aggregates on a more or less continuous basis. This is a misreading of our intent. We believe that the nation would be ill-served by a mechanical application of monetary rules. We know that large, erratic, and unpredictable short-run changes often occur in demands for money and credit. One of the important functions of a central bank is to prevent such short-run shifts from interfering with the

Chart 1



smooth functioning of money and capital markets. We have no intention of abandoning our responsibilities in this area (3)."

By 1975, however, the Federal Reserve had come to focus its stated policy intentions on the monetary aggregates. The FOMC's quarterly choice of growth rates for M_1 and M_2 became an index of FOMC policy intentions in the six to twelve months following their selection.

The present FOMC Directive provides operating instructions to the SOMA in terms of "short-term tolerance ranges," one for the M_1 and M_2 monetary aggregates, and one for the Federal-funds rate. For example, in its July 19, 1977 meeting, the FOMC voted the following Directive:

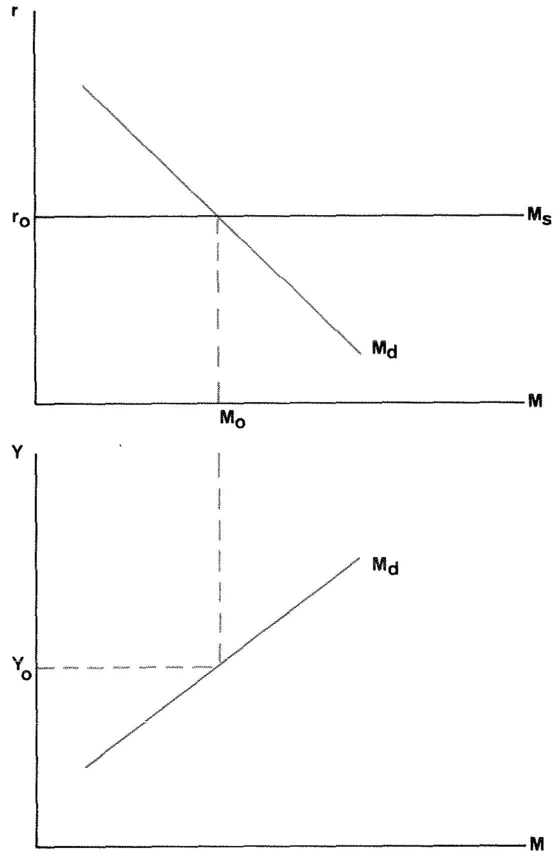
> "Specifically at present, it [the FOMC] expects the annual growth rates over the July-August period to be within the ranges of 3½ to 7½ percent for M_1 and 6½ to 10½ percent for M_2. In the judgment of the Committee such growth rates are likely to be associated with a weekly-average Federal funds rate of about 5⅜ percent. If, giving approximately equal weight to M_1 and M_2, it appears that growth rates over the two month period will deviate significantly from the midpoints of the indicated ranges, the operational objective for the Fedral funds rate shall be modified in an orderly fashion within a range of 5½ to 5¾ percent (5)."

The SOMA's basic task is to achieve, on a weekly average basis, the "midpoint" of the short-term tolerance range for the Federal-funds rate. However, the appropriate SOMA response to unanticipated growth in the monetary aggregates is still not spelled out explicitly in the Directive, although the desirability of *some* response is certainly suggested.

The lack of an explicit link in the Directive between the aggregates target and the funds-rate target, as well as occasional statements by Fed officials, raises the question of whether the Federal Reserve actually responds more than before to unintended growth in the monetary aggregates. Former Federal Reserve insiders sometimes suggest that the monetary aggregates are not given much attention in practice. James Pierce, former associate economist for the FOMC, is quoted to this effect in the March 27, 1978, issue of *Fortune* magazine:

> "...The Fed still conducts its business virtually the same way it always has. When Congress passed its 1975 resolution, it intended the Fed to pay more attention to the growth of the monetary aggregates—M_1, M_2, etc.—and less attention to stabilizing interest rates. Since 1975 the Fed has paid more and more lip service to the monetary aggregates... (10)"

Chart 2

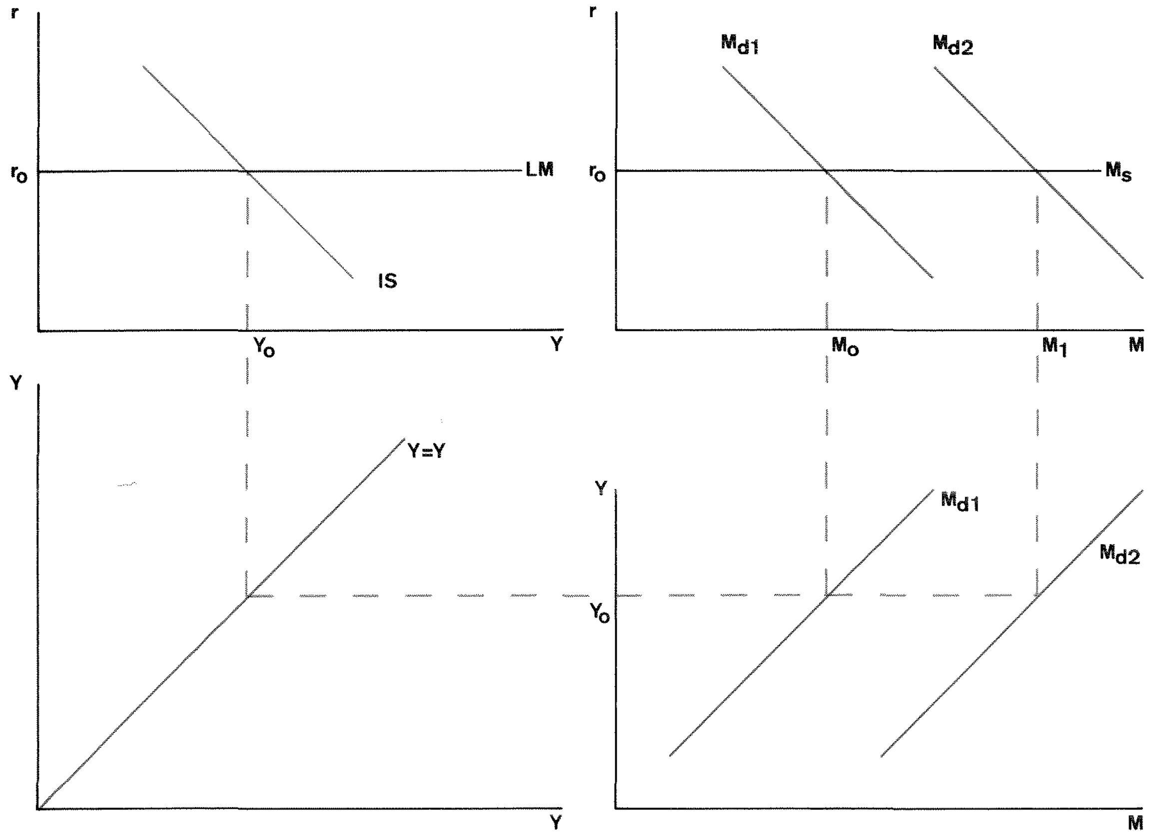


II. Has the Fed's Behavior Changed?

In the economics textbooks, the Fed is described as having two options when implementing policy: 1) control interest rates, or 2) control the money stock. In reality, however, the second option is not a simple one under the current institutional framework. The amount of money (M_1) is jointly determined by the Fed, the commercial banks and the public at large. Moreover, it is partly estimated, rather than measured, by the Fed, so the word "control" is not quite applicable. A better description would be to say that the Fed has the choice either of changing interest rates, or of not changing them, in response to unanticipated behavior of the money stock. In this section we argue that the Fed has recently "controlled" the money stock to some degree—that is, the Fed has changed its interest-rate plans in response to unanticipated changes in M_1—in ways that it did not during the 1960's.

This argument is based upon the changes that have occurred over time in money–stock market relationships. Most economists agree that the stock-market response to M_1 is important evidence of M_1's impact on economic activity in general, because the stock market is an efficient market. That is, stock-market behavior reflects accurate forecasts (rational expectations) of future economic activity. In the words of William Poole, "The validity of the rational-expectations (efficient market) hypothesis as applied to prices in active auction markets has been extensively tested. Numerous investigators have analyzed an enormous amount of data using many different statistical techniques, and no serious departure

Chart 3



from the predictions of the hypothesis has been found (12)."

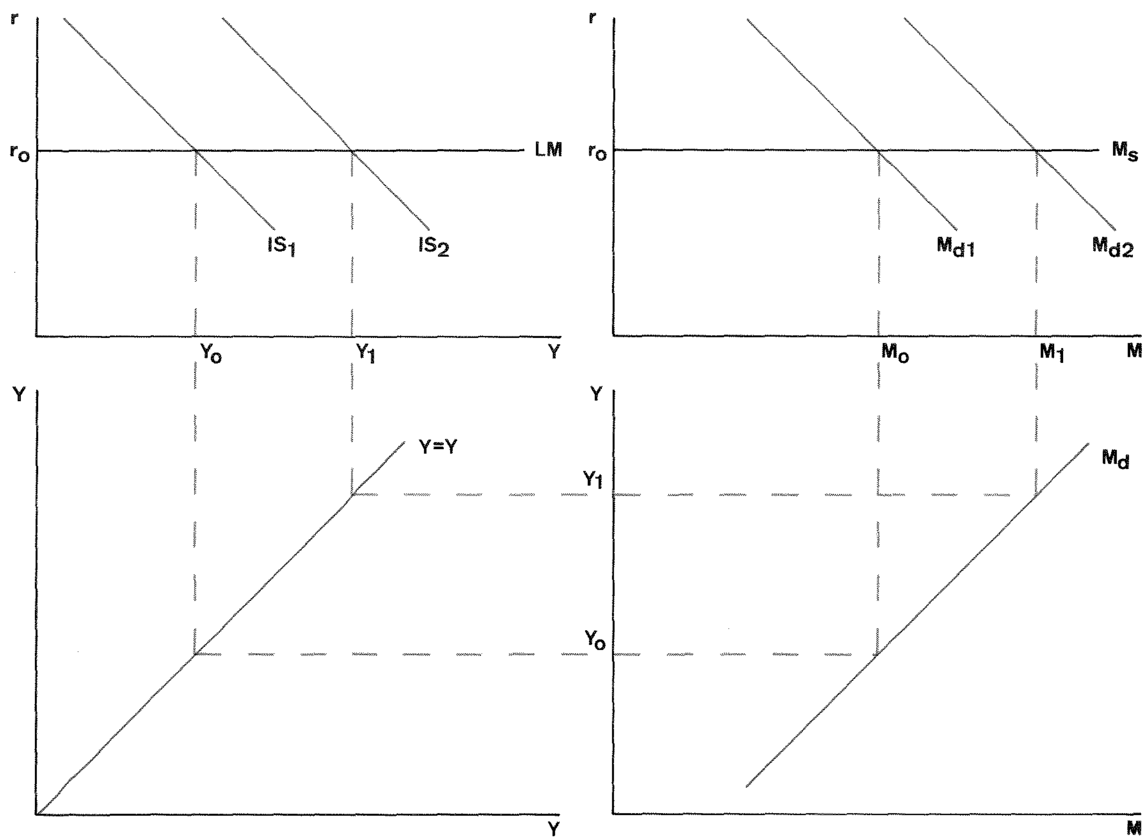
According to the efficient-market hypothesis, all relevant available information affecting a firm's future net revenues is accurately reflected in its current stock value. With an efficient stock market, the market's response to a change in the money supply occurs as soon as market participants compute the economic impact of a change in M_1. In particular, an efficient stock market would adjust for any change in Federal Reserve response to M_1 growth.

We attempt to show here that the Federal Reserve, under certain circumstances, is the decisive factor in determining the economic effects of a given change in M_1. Next, we present evidence of a reversal, since 1970, of the stock market's response to M_1 changes. Since that turning point, increases in the money supply have tended to have negative rather than positive impacts on stock prices. This suggests a shift over time in both the Fed's response and the economy's response to changes in M_1.

Consider the standard IS-LM model of income determination (Chart 1). Income (Y) and interest rates (r) are determined by joint equilibrium of the markets for goods and services (IS) and for money (LM). The IS curve represents various equilibrium combinations of interest rates and income in the market for goods and services. The curve is negatively sloped to indicate that households and firms will purchase relatively more goods and services if interest rates decline, other things equal. The LM curve represents various combinations of interest rates and income that lead to equilibrium in the money market. It is sometimes constructed with an upward slope and sometimes horizontally, depending on the Fed's behavior. In this case the LM curve is horizontal, because the Fed controls interest rates over the very short-run.

The short-run structure of the money market

Chart 4



may be summarized by: 1) a standard money-demand function, where money demand is directly proportional to nominal income and inversely related to interest rates; and 2) a horizontal short-term money-supply function, where the Federal Reserve implements policy by choosing a particular level of the Federal-funds rate and supplying the cash necessary to maintain this level. Chart 2 summarizes the money market under these conditions, with equilibrium interest rate r_0 and income y_0.

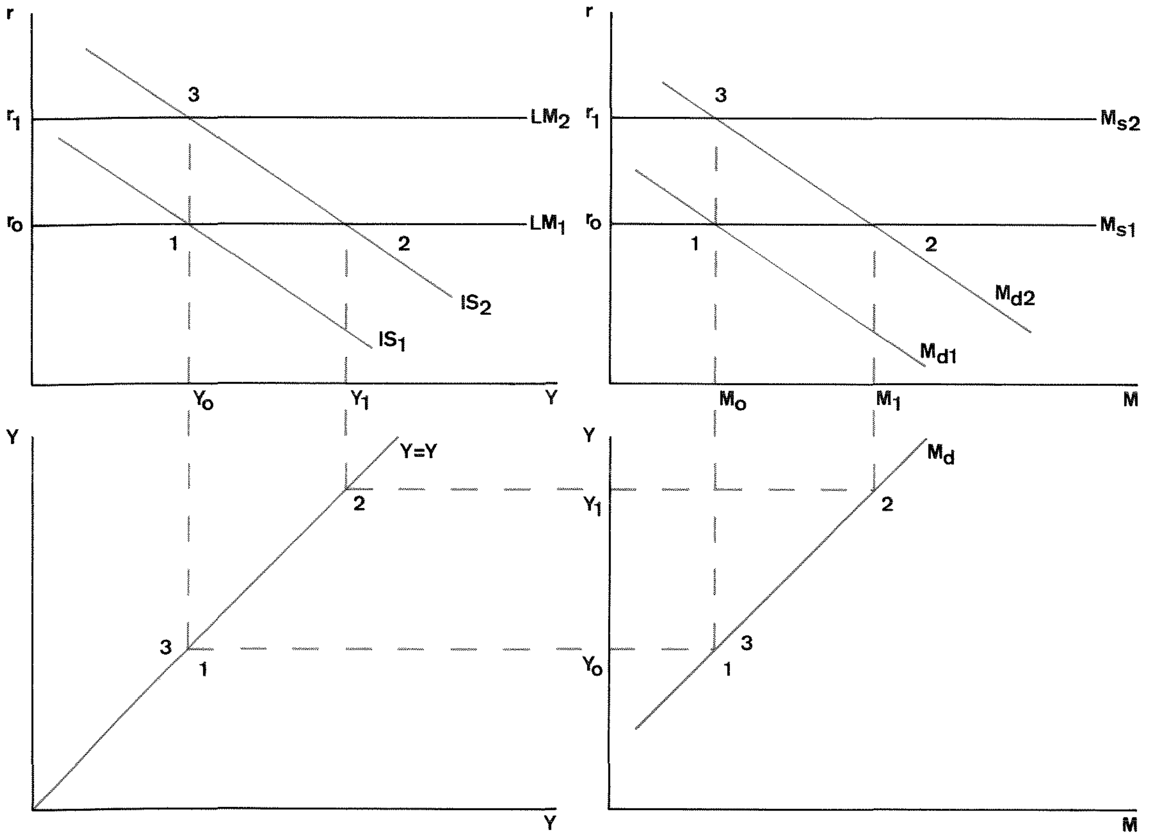
Consider first a policy where the Fed does not respond to changes in the money supply. If there were an unanticipated increase in the money supply, would income be permanently higher as a result? The answer depends on the source of the increased money.

One possible source would be an upward shift in the demand for money at old levels of income (Chart 3). Such a change in money demand would mean more money, an increase from M_0 to M_1, but the IS-LM relationship would be unaffected and income and interest rates would be unchanged.

A second possible source would be an increase in money demanded due to an outward shift in the IS curve (Chart 4). An unanticipated increase in money of this sort would tend to be associated with higher future income. Except in those cases where the increased quantity of money is due to an upward shift in money demand, there is a positive probability of greater future income with a surprise increase in money. In Appendix I this proposition is demonstrated analytically.

Now suppose the Fed becomes sensitive to the behavior of money under a policy of practical monetarism. In this situation, an unanticipated increase in the money supply would lead the Fed to increase its funds-rate target. But if the source of the increased money was a shift in the IS curve, the increase in the funds-rate target would

Chart 5



tend to offset the otherwise higher level of future income (Chart 5). The chart shows (1) the initial equilibrium, (2) the equilibrium after the surprise increase in the supply of money due to the shift in the IS curve, and (3) the equilibrium at old levels of income and higher interest rates after the Fed responds to the unanticipated change in money by raising the funds-rate target.

As our analysis suggests, the IS-LM model does not by itself lead to any single conclusion about the future of interest rates and income following an unanticipated change in money, independently of Federal Reserve policy. The effect of an increase in M_1 depends on whether or not the Fed intends to offset this increase by returning to former money-growth rates. If the Fed does not raise interest rates in this situation, an increase in money will tend to result in more rapid income growth and unchanged interest rates. If the Fed does respond to increased M_1 growth, future income will remain unchanged and future interest rates will tend to rise.

The effect of an increase in M_1 upon an efficient stock market depends upon the policy choice made by the Federal Reserve. The efficient stock market equates the value of stock to the discounted value of future net earnings of the firm

$$V_t = E_0 + \frac{E_1}{1 + r} + \frac{E_2}{(1 + r)^2} + \ldots$$

where

V_t = value of a share of stock at time t

E_i = earnings per share of stock at time (t + i)

r = rate of interest

Consider the case where the Fed sets its interest-rate targets independently of money growth (Chart 6). In the short run, earnings depend on demand-induced changes in aggregate spending. Although policy-induced increases in aggregate demand will eventually affect costs as well, the initial effect of an increased rate of income

Chart 6

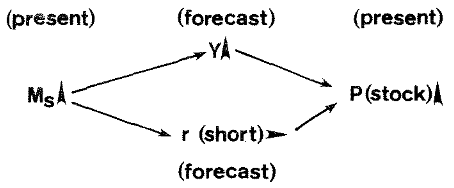
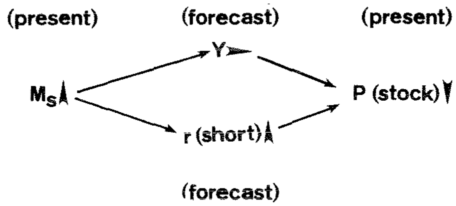


Chart 7



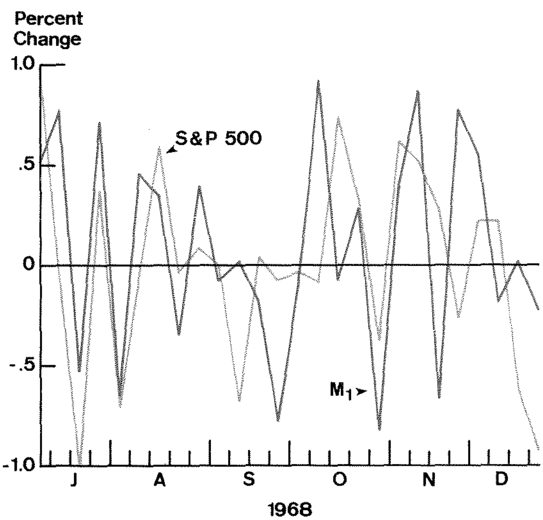
growth will be an increase in the firm's net earnings. Thus, if the Fed does not respond to increased M_1, the resulting higher income and unchanged interest rates would lead to an increase in stock prices.

Next, consider the case where the Fed raises its interest-rate targets in response to money growth (Chart 7). Income and expected earnings would not increase. Instead, the stock market would anticipate a rise in interest rates, which would tend to raise the discount applied to future earnings and to lower the value of stock. Thus, efficient-market-determined stock values, like economic developments, depend in the last analysis upon the Fed's response to money growth. If the market expects the Fed to offset a given increase in M_1 growth, the result would be lower stock values.

Chart 8

M_1 and STOCK PRICES

June 27 - December 27, 1968



Most empirical studies of the subject, based entirely or predominantly upon 1960's data, have found a positive correlation between changes in the money supply and changes in stock prices. Most of these studies have utilized monthly or quarterly average behavior of the two variables, but similar results have been obtained with weekly-change data for second-half 1968—specifically, the Federal Reserve's money data released each Thursday after the stock-market close, and the closing stock-price data released the following Friday (Chart 8). However, a completely different picture emerges when we compare the same two variables in a more recent period, the first half of 1977 (Chart 9). In this period, we observe a negative rather than a positive relationship between money and stock prices.

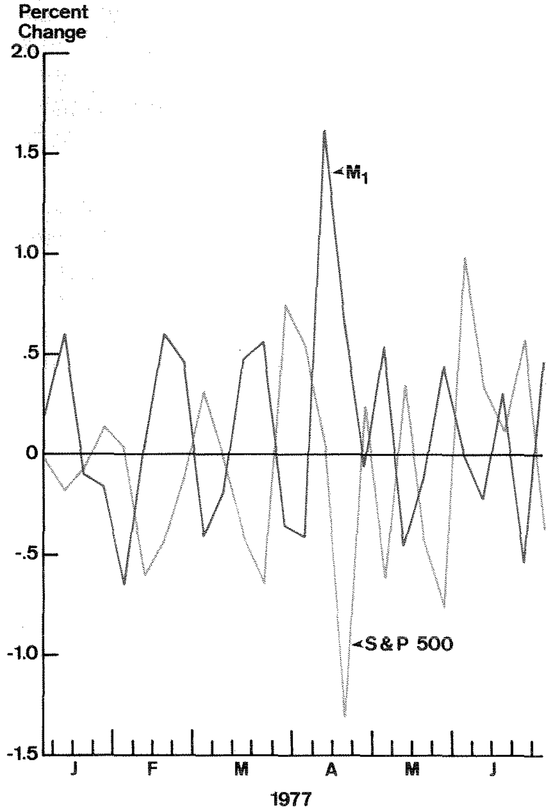
To capture the entire effect of the monetary impact on the stock market, we may have to take account of microeconomic as well as macroeconomic effects. According to a micro approach, an unexpected increase in current money balances in an individual portfolio leads to an undesirably high ratio of money to other assets. As a result, savers attempt to reduce their holdings of other types of assets so as to restore their money-earning assets ratios to preferred levels.

Changes in the money supply could have both kinds of effects. Microeconomic effects, which can occur at any time, involve market participants as they make portfolio decisions that directly affect stock prices and perhaps ultimately the economy as a whole. Macroeconomic effects, which occur only at one specific time, involve market participants as they adjust their economic forecasts in response to new money data. The microeconomic effects of money growth are always positive, while the macroeconomic effects may be either positive or negative.

If the micro effects are dominant, then the behavior shown in the charts would represent only irrelevant "announcement effects" and would be dominated by the "actual effects" of the money-stock price relationship. But a separate statistical analysis (Appendix II) supports the thesis suggested by the charts -- namely, that the inverse macro relationship dominates the positive micro relationship. This inverse relationship is evident in the 1973-77 period, and especially in 1975-77. The statistical evidence also suggests that, because of changing Federal Reserve behavior, the market has reversed the macroeconomic effects expected from unanticipated changes in M_1.

Chart 9

M_1 and STOCK PRICES
January 6 - June 30, 1977

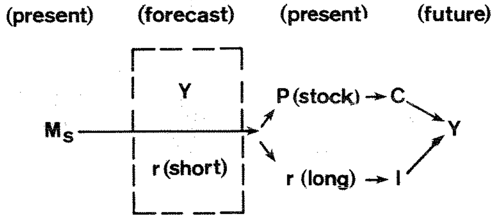


III. Transmission of Money Growth to the Economy

What is the mechanism that transforms changes in money into changes in the level of economic activity? Chart 10 indicates that changes in money immediately affect stock prices and long-term interest rates, because these changes cause market participants to revise their forecasts of future income and interest rates.

If holders and prospective holders of long-term bonds decide that short-term rates will rise more than originally anticipated, they will bid up long-term rates as a means of arbitraging the higher expected short-term yield. This change in short-

Chart 10



(present) (future)

term rate forecasts also would increase the discount on future corporate revenues and reduce stock values.

Consider the 1960's-style response to a surprise increase in M_1 (Chart 11). Since market participants would expect the Federal Reserve to accommodate such unanticipated increases, the result would be higher forecasts of income and unchanged forecasts of interest rates. These forecasts would tend to push stock valuation upward, and leave long term rates unchanged. The booming stock market stimulates consumer spending, which leads to higher levels of income.

Next, consider the 1970's-style response to a surprise increase in M_1 (Chart 12). Since market participants would expect the Fed to offset such unanticipated increases, they would revise their short-rate forecasts upward but leave income forecasts unchanged. The initial effects

Chart 11

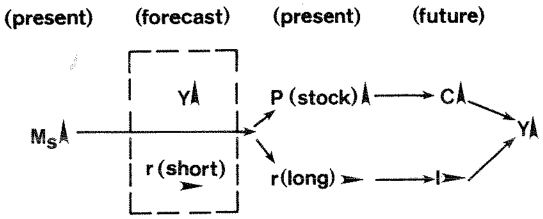
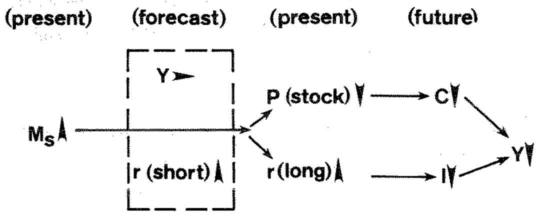


Chart 12



would be higher long rates and lower stock prices, which in time would tend to reduce consumption and investment and therefore reduce income.

The stock market's recent behavior casts doubt on the idea that the portfolio-adjustment process is primarily a response to a disequilibrium amount of money in current portfolios. The evidence suggests that a change in the *anticipated* rate of money growth is more important than *current* monetary changes in explaining portfolio adjustment. In the 1960's, an unexpected increase in money had a positive impact on the stock values, because it suggested accelerated future money growth (due to accelerated future GNP growth). In the 1970's, however, a similar increase in money was contractionary, because it meant slower future money growth (due to the Fed's raising of interest rates at current GNP growth rates).

If changes in anticipated future rates of money growth are more important than current changes, the emphasis should be on *anticipated* future excess supplies. Then the substitution of equities for money that would drive the system into equilibrium would be a substitution of future claims to money for current holdings of equity -- in other words individuals would tend to buy equity on credit. Replacing a current excess supply of money with a future excess supply would make the inverse money-stock price relationship consistent with the portfolio-adjustment model.

IV. Summary and Conclusions

The apparent reversal in the stock market's response to a change in money should ease the Fed's attempt to reduce fluctuations in income. In the case of an unanticipated decline in M_1, market participants would expect the Fed to lower interest rates as a means of offsetting the associated decline in income, and thus they would act to push equity values upward and to reduce long-term interest rates. Rising stock values would increase net wealth and therefore increase consumption spending out of net wealth, thus bringing about the beneficial effect on income growth desired by the Fed. Similarly, long-term rates would tend to fall in anticipation of the Fed's intention to reduce future short-term rates. This decline in long-term rates would increase investment expenditures, again moving the economy in the direction desired by the Fed.

However, the effect of efficient auction markets upon the economy can be a two-edged sword. Suppose the Fed made an error the stock market was aware of -- for example, by choosing a "wrong" money growth target that led to a higher growth in income than the Fed desired. Market participants then would re-evaluate firms' expected revenues, and stocks would appreciate in value. Likewise, traders would reduce the levels of expected short-term interest rates, bringing long-term rates down. Both results would exacerbate the initial policy mistake and lead to excessive growth in income.

The stock market thus can be a useful indicator of the impact of monetary policy. If the actions of policymakers are consistent with their desires, the stock market should reflect this fact. In contrast, if their policy is more restrictive than desired, the results would be seen in an undesirably weak stock market.

Most past studies of relationships between the stock market and other economic variables have focused upon past events that have affected present stock values. But if the stock market is efficient, this is not the right order of influence. With an efficient market, the key influence is the *future* behavior of key economic variables -- or at least the best available estimate of their behavior.

As a consequence, the stock market can help judge the future course of monetary policy. According to the evidence developed here, the Fed's response to unanticipated behavior of M_1 has changed substantially—so substantially, in fact, as to *reverse* the earlier implication of how changes in money growth would affect the average firm's future net income.

In addition, the market's response to M_1 has an economic impact all its own. This helps the Fed in achieving its goals when the Fed's estimate of future economic activity coincides with the market's estimates. However, the market will thwart the Fed's intentions when it thinks the Fed's forecasts are mistaken.

APPENDIX I

In this appendix we derive the economic impact of unanticipated changes in the money supply under two different monetary-policy procedures, using the IS-LM model:

$$y_t = a_o + a_1 r_t + p_1 y_{t-1} + e_t$$

$$m_t = b_o + b_1 y_t + b_2 r_t + p_2 m_{t-1} + u_t$$

y_t = nominal income in period t
m_t = amount of money in period t
r_t = interest rate in period t
e_t, u_t = independent normally distributed random variables with mean zero and variances σ_e^2 and σ_u^2 respectively.

First we consider a monetary policy which is formulated independently of changes in M, so that the course of future interest rates will not be influenced by an unanticipated increase in the money supply. Stock-market participants, knowing this, will assume future interest rates unchanged. In forming estimates of the unanticipated increase in current income associated with the surprise increase in money, traders may base their initial income forecast, y_o, upon an IS curve relationship and upon an LM curve relationship:

$$\text{IS} \quad \Delta\hat{y}_o = 0$$

$$\text{LM} \quad \Delta\hat{y}_o = b_1{}^{-1}\Delta m_o$$

in order to minimize the variance, the two forecasts would be weighted according to the size of the associated forecast errors:

$$\hat{y}_o = c_1\,(0) + c_2\,(b_1^{-1}\,\Delta m_o)$$

where

$$c_1 = \frac{(b_1^{-1})^2\sigma_u^2}{(b_1^{-1})^2\,\sigma_u^2 + \sigma_e^2}$$

$$c_2 = \frac{\sigma_e^2}{(b_1^{-1})^2\,\sigma_u^2 + \sigma_e^2}$$

After this inital period, the increased income associated with the unanticipated increase in money will result from the auto-correlation in income implicit in the IS curve:

$$\Delta y_i = p_1 \Delta y_{i-1}$$

So that $\Delta y_i = p_1^i \, c_2 b_1^{-1} \, \Delta m_o$.

Since $p_1, c_2, b_1^{-1} > 0$,

$$\frac{\Delta y_i}{\Delta m_o} > 0, \frac{\Delta r_i}{\Delta m_o} = 0.$$

Next, we consider a monetary policy where interest rates respond to unanticipated changes in the money supply. The first-round effect of this surprise change is the same as before. However, the Fed is now using the minimum variance estimate of the current increase in income derived above, and attempting to offset its effect on future income by raising interest rates. This increase in interest rates is:

$$\Delta r_1 = -a_o^{-1} p_1 \, \hat{\Delta} y_o$$

The resulting equations for changes in interest rates and income associated with the unanticipated change in the money supply is:

1) $\hat{\Delta} y_o = c_2 b_1^{-1} \, \Delta m_o$

2) $\hat{\Delta} y_i = 0 \quad i = 1, 2, \ldots$

3) $\hat{\Delta} r_1 = -a_1^{-1} c_2 b_1^{-1} \Delta m_o$

$\qquad c_2, b_1^{-1} > 0, a_1^{-1} < 0$

4) $\hat{\Delta} r_i = 0 \qquad i = 2, \ldots$

APPENDIX II

This appendix contains a time-series analysis of the impact of a given percentage change in the money supply upon stock prices.

A convenient way of expressing the value of a share of stock, V_t, at any point in time is:

$$V_t = \sum_i (R_i - C_i) \frac{1}{(1 + r)^{(t-i)}}$$

$$i = t, t + 1, \ldots$$

where R_i = anticipated revenues in period i
C_i = anticipated costs in period i
r = the interest rate.

This in turn provides us with a formula for the change in the price of a share of stock in a given time period:

$$\Delta V_t = \sum_i \Delta (R_i - C_i) \frac{1}{(1 + r)^{t-i}} - D_t$$

where D_t = dividends paid during period t.

That is, the change in share prices in any period ${}_{t-1}\Delta_t$ is the change in the present value of anticipated net revenues less the dividends paid during the period.

Adding dividends to both sides:

$$E_t = D_t + \Delta V_t$$

$$= \sum_i \Delta (R_i - C_i) \frac{1}{(1 + r)^{t-i}}$$

$$= f({}_{t-1}X_t) + E$$

where

E_t = earnings due to holding a share of stock during the period from time t−1 to time t.

E = anticipated earnings due to holding a share of stock at time t−1.

${}_{t-1}X_t$ = vector describing the information important to stockholders that is learned between time t−1 and time t.

Given an efficient stock market, money-supply changes also affect stock values to the extent that they affect the "best" forecasts of real economic variables. This means that money-supply behavior that does not *change* the economic forecast also has no impact on the value of stock. While money changes might affect real economic activity with a time lag, they would affect *forecasts* of future economic activity immediately, and so the effect on the stock market would also be immediate. Similarly, the part of a change in the money supply that was expected to occur would already be included in current economic forecasts, and hence would already be reflected in stock values at the time it occurs. So only unanticipated money changes have any impact upon stock values. Therefore, in an efficient stock market, changes in stock values between, say, time t−1 and time t would *not* be related to:

1) money-supply changes that occur prior to time t-1, and
2) money-supply changes that occur after time t−1 but are anticipated at time t−1.

In short, the only changes in the money supply that potentially affect stock values are those that are unexpected and occur during the same time period as the change in stock values.

To develop an appropriate measure of the change in stock values, we used an updated version of the Standard and Poor Index of the end-of-the-month return to stock. (Ibbotson and Sinquefield, "Stocks, Bonds, Bills, and Inflation: Year by Year Historical Returns (1926-1974)," *Journal of Business,* Vol. 4a). It was then necessary to develop an appropriate measure of the new information provided by M_1 during the month in which stock values were affected—that is, M_1 data available to financial-market participants at the time, rather than later revisions. For this reason, M_1 data were based on last-Wednesday-of-the-month releases from the Federal Reserve Statistical Release H-6, Table 1.

In order to find the unanticipated change in the money supply over a given time period, we first had to develop some sort of estimate of the anticipated change in M_1. If stock-market participants are rational, they would at least use all the information provided by the past behavior of the money supply itself. In other words, to the extent that money growth follows predictable patterns, past values are useful in forecasting the future money supply. We use the standard Box-Jenkins analysis to develop the information from past money-supply behavior efficiently.

Since the basic hypothesis was that monetary-policy techniques had shifted between the 1960's and the 1970's (particularly after 1975), it seemed logical to form different estimates of anticipated money for the different periods considered. Initially, three time periods were examined: January 1960 - December 1969, January 1970 - December 1976, and January 1973 - December 1976 (Table 1). The table describes lags at which significant autocorrelation existed between the M_1 change in a given month and M_1 changes k months in the past. (Significance was based on one standard deviation of the asymptotic distribution of the autocorrelation term, under the null hypothesis that inter-period changes in M_1 are independent. With independence, autocorrelation terms are asymptotically normal with zero mean and variance $1/N$ where N is the size of the sample.)

Table 1
Structure of Autocorrelation (up to 20 lags) of M_1 Percentage Change (monthly) in Different Time Periods

Test statistic $N^{-1/2}$ =	.091	.109	.145
Sample period:	Jan. 1960 - Dec. 1969	Jan. 1970 - Dec. 1976	Jan. 1973 - Dec. 1976
Significant autocorrelations at k =	2	1	1
	3	4	4
	4	7	7
	6	8	8
	11	11	11
	17	12	15
	18	14	17
	19	15	
		17	
		19	

Based on these results, we constructed the following equations (see Table 2) for the purpose of estimating anticipated money. Q statistics indicate that an χ-square test will permit acceptance of the hypothesis that the residuals of the anticipated money series are uncorrelated. Thus, we may reject the hypothesis that there is more information about the current change in M_1 contained in past behavior of M_1 after the adjustment.

After forming monthly forecasts of M_1 change based upon the information contained in past money behavior, we subtract the forecasts from the actual change to get some measure of the surprise change in M_1. We can then compare the unanticipated change to the change in stock valuation to determine if there is a relationship between the two variables. Most recent studies of this relationship have been based upon data from the 1960's and early 1970's. The evidence they present is not conclusive, but they generally support the proposition that the market for stock is efficient, according to the criterion that "old" M_1 data has no identifiable effect on the stock market. (See for example Rogalski and Vinso, *Journal of Finance,* September 1977 for an examination of the efficiency with which the stock market uses monetary data.) Our evidence on the subject is also not conclusive, at least for the 1960-69 period. In that period, surprise changes in the money supply apparently had some predictable relationship to changes in stock values in future periods. However, later data show no such relationship, and therefore support the efficiency hypothesis (Table 3).

Table 2

Filter for M_1 Change (percent) for 1960 - 1969

Equation Lag	2.	3.	4.	6.	9.	11.
Coefficient	−0.10181	−0.27571	0.09436	−0.26240	−0.12015	−0.11795

Autocorrelations of Residuals											Q Statistics
1 − 10	0.06	0.02	−0.02	0.00	0.05	0.03	0.01	−0.02	0.03	0.00	0.999
11 − 20	−0.00	−0.05	0.01	−0.07	0.06	0.07	0.13	0.03	−0.08	0.10	7.091

Summary Statistics
Variance of Residuals = $.1257 \times 10^{-4}$, degrees of freedom = 113
Durbin-Watson Statistic = 2.097
$R^2 = .155$

Filter for M_1 Change (percent) 1970 - 1976

Equation Lag	1.	4.	7.	8.	9.	11.
Coefficient	0.16914	0.04699	0.19062	0.06291	−0.26921	−0.24289

Autocorrelations of Residuals											Q Statistics
1 − 10	−0.02	−0.07	0.01	−0.01	−0.02	−0.03	0.02	0.08	−0.03	−0.04	1.417
11 − 20	0.03	−0.13	−0.06	0.10	−0.15	0.08	0.18	−0.00	0.03	−0.05	9.466

Summary Statistics
Variance of Residuals = 0.0422×10^{-4}, degrees of freedom = 77
Durbin-Watson Statistic = 1.920
$R^2 = .125$

Filter for M_1 Change (percent) 1973 - 1976

Equation Lag	1.	2.	4.	5.	7.	8.
Coefficient	0.29351	0.31124	0.53073	−0.37976	0.04356	−0.00996

Autocorrelations of Residuals											Q Statistics
1 − 10	−0.04	−0.01	0.09	0.03	−0.02	−0.09	−0.00	0.07	0.09	−0.01	1.466
11 − 20	0.09	−0.10	0.05	0.03	−0.25	−0.03	0.20	−0.07	−0.05	−0.11	8.207

Summary Statistics
Variance of Residuals = 0.2729×10^{-4}, degrees of freedom = 41
Durbin-Watson Statistic = 1.964
$R^2 = 0.269$

Other studies have found a significant relationship between changes in the stock values in a given week and unanticipated M_1 changes in following weeks — a sort of reverse causality running from the stock market to the money supply. One reasonable explanation for this behavior is that stock-market participants can find available other (non-money) information useful in forecasting future M_1 changes prior to the publication of M_1 data. In this case, changes in stock values will tend to precede unanticipated changes in the money supply, because market participants are partly able to anticipate them.

In all three periods, we found some indication of a relationship between present stock prices and future changes in the money supply, but the relationship was stronger after 1970. In the case of the 1975 to 1976 residuals, significant relationships appear to exist between changes in the value of stock and unanticipated money and next week's unanticipated money. This result is consistent with the hypothesis of an efficient stock market that believes unanticipated increases in the money stock have an adverse effect upon the discounted net earnings of the average firm.

Table 3
Correlations of Unanticipated Monthly Percentage Change in M_1 with Monthly Percentage Change in Stock Values at Various Leads and Lags

I. January 1960 – December 1969

a) contemporaneous correlation p = 0.117*

b) correlation between stock and M_1 i periods in the past

i =	1	2	3	4	5	6	7	8	9	10	χ^2
p =	0.111*	0.217*	0.034	0.090	−0.044	−0.053	0.005	0.077	−0.069	−0.121	11.67

c) correlation between stock and M_1 i periods in the future

i =	1	2	3	4	5	6	7	8	9	10	χ^2
p =	0.061	0.025	−0.112*	−0.003	0.014	0.017	−0.037	−0.366*	0.072	−0.042	19.02

*significant with critical value $1/\sqrt{N}$ = .096

II. January 1973 – December 1976

a) contemporaneous correlation p = −0.107

b) correlation between stock and M_1 i periods in the past

i =	1	2	3	4	5	6	7	8	9	10	χ^2
p =	−0.091	−0.060	−0.192*	0.215*	0.159*	0.190*	0.054	−0.146*	0.058	−0.195*	9.39

c) correlation between stock and M_1 i periods in the future

i =	1	2	3	4	5	6	7	8	9	10	χ^2
p =	−0.417*	−0.061	−0.124	−0.049	−0.132	−0.095	0.095	0.092	−0.195*	−0.050	13.18

* significant with critical value $1/\sqrt{N}$ = .144

III. Residuals from January 1975 - December 1976 based on anticipated money series constructed using January 1973 - December 1976 M_1 data.

a) contemporaneous correlation p = −.368*

b) correlation between stock and M_1 i periods in the past

i =	1	2	3	4	5	6	χ^2
p =	−0.115	−0.169	−0.059	0.135	0.003	0.188	1.958

c) correlation between stock and M_1 i periods in the future

i =	1	2	3	4	5	6	χ^2
p =	−0.461*	−0.086	−0.232	−0.135	0.163	0.012	7.648

* significant with critical value $1/\sqrt{N}$ = .209

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