DALLASFED

Economic Review

Federal Reserve Bank of Dallas
March 1988

Just as the strong dollar slowed the rate of growth in U.S. manufacturing during the first half of the 1980s, the fall in the dollar that began in early 1985 should stimulate U.S. manufacturing during the rest of the decade. The production responses from individual manufacturing industries are likely to vary, however, because the dollar has effectively fallen more for some industries than for others. In addition, some industries are generally more sensitive to changes in exchange rates. Because the composition of manufacturing varies regionally, the manufacturing sectors of some states also are likely to prosper more than others from dollar declines.

Many analysts contend that an expansionary monetary policy lowers interest rates. Through this so-called liquidity effect, policy actions are thought to generate movements in real economic variables. In this article, evidence from an efficient-markets approach to interest rate determination finds no support for such an effect on long-term interest rates. In fact, an expansionary monetary policy is found to be associated with an increase in long-term rates. The evidence indicates that this relationship appears to have emerged in the decade of the 1980s.

This publication was digitized and made available by the Federal Reserve Bank of Dallas' Historical Library (FedHistory@dal.frb.org)

Economic Review

Federal Reserve Bank of Dallas
March 1988

President and Chief Executive Officer
Robert H. Boykin

First Vice President and Chief Operating Officer
William H. Wallace

Senior Vice President and Director of Research
Harvey Rosenblum

Vice President and Associate Director of Research
Gerald P. O'Driscoll, Jr.

Assistant Vice President and Assistant Director of Research
W. Michael Cox

Assistant Vice President and Senior Economist
Leroy O. Laney

Economists

National/International
Robert T. Clair
John K. Hill
Joseph H. Haslag
Cara S. Lown
Kenneth J. Robinson

Regional/Energy
Stephen P. A. Brown
William C. Gruben
Hilary H. Smith
William T. Long III
Jeffery W. Gunther
Keith R. Phillips

Editorial
Virginia M. Rogers
Elizabeth R. Turpin

Graphics and Typesetting
Graphic Arts Department

The *Economic Review* is published by the Federal Reserve Bank of Dallas and will be issued six times in 1988 (January, March, May, July, September, and November). The views expressed are those of the authors and do not necessarily reflect the positions of the Federal Reserve Bank of Dallas or the Federal Reserve System.

Subscriptions are available free of charge. Please send requests for single-copy and multiple-copy subscriptions, back issues, and address changes to the Public Affairs Department, Federal Reserve Bank of Dallas, Station K, Dallas, Texas 75222 (214/651-6289).

Articles may be reprinted on the condition that the source is credited and that the Research Department is provided with a copy of the publication containing the reprinted material.

Effects of the Lower Dollar on U.S. Manufacturing: Industry and State Comparisons

W. Michael Cox

Assistant Vice President
and Assistant Director of Research
Federal Reserve Bank of Dallas

John K. Hill

Senior Economist
Federal Reserve Bank of Dallas

Growth in U.S. manufacturing production slowed significantly during the first half of the 1980s. After rising at an average annual rate of 2.7 percent during 1969-79, manufacturing output increased at a rate of only 1.8 percent during 1979-85. Much of this slowdown has commonly been attributed to changes in the foreign exchange value of the dollar. For the period September 1980 – March 1985, the inflation-adjusted dollar rose 37 percent against a trade-weighted average of the currencies of U.S. trading partners.[1] By making U.S. goods more expensive relative to foreign goods, the appreciation of the dollar thus served to reduce world demand for U.S. manufactured products.

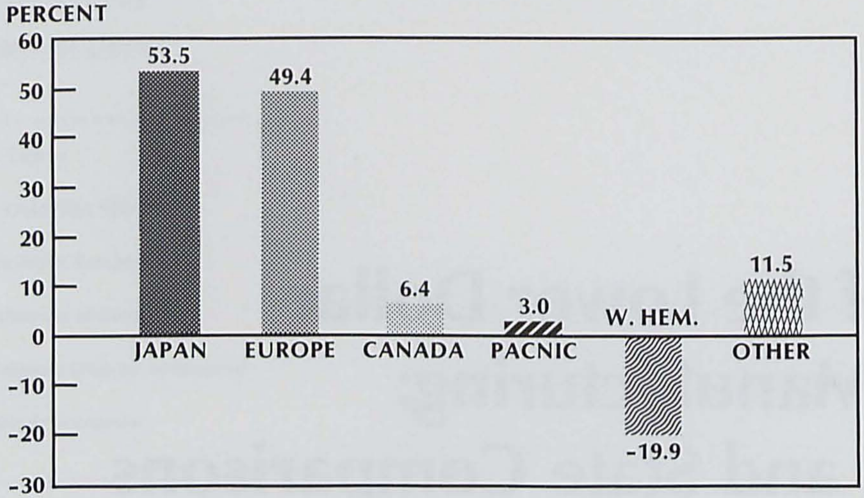
Beginning in early 1985, however, the dollar reversed its course. By the middle of 1987, the dollar had declined 23 percent on a broad basis, giving up nearly two-thirds of its earlier gains. In view of the present persistence of the U.S. trade deficit, further declines in the dollar are also possible.

Just as the strong dollar has served to slow the rate of growth in U.S. manufacturing during the first half of the 1980s, the lower dollar should provide a stimulus to U.S. manufacturing during the second half of the decade. The benefits, however, likely will not be distributed evenly across individual industries and states. Because the dollar has depreciated at different rates against the various currencies and because industries differ in their exposure to trade with a particular country, the dollar in effect has fallen more for some industries than for others. Substantial differences also exist across industries in the sensitivity of production to changes in exchange rates. For these reasons, the fall in the dollar likely will elicit a variety of production responses from U.S. industries. And in view of the geographic concentration of manufacturing production, important regional imbalances probably will be associated with the lower dollar.

The purpose of this article is to identify those industries and states likely to benefit the most from recent declines in the dollar. First, the amount of dollar depreciation that has occurred since early 1985 was calculated for each two-digit

The authors would like to thank Franklin D. Berger for computational assistance and Stephen P. A. Brown for helpful conversations during the formative stages of this research.

Figure 1
Depreciation in Real Value of the Dollar, by Country Group, March 1985–June 1987



SOURCE: Federal Reserve Bank of Dallas.

Standard Industrial Classification manufacturing industry. Information on trade exposure and product substitutability was then used to determine the sensitivity of industry production to changes in exchange rates. Finally, the results were combined to form estimates—by industry and state—of the effects of the lower dollar on U.S. manufacturing production.

The research for this study supports the following conclusions. The industries projected to benefit substantially from the lower dollar include transportation equipment, instruments, electronic equipment, nonelectrical machinery, and chemicals. For these industries, recent movements in the dollar have been particularly favorable, and their production is relatively sensitive to exchange rate changes. In contrast, the production of lumber and wood products, pulp and paper, textiles, and processed food is not expected to respond significantly.

The findings for this study also indicate substantial regional disparities in the projected benefits of the lower dollar. An above-average response is expected for much of the Northeast, Upper Midwest, and West. But below-average gains are projected for the Southern Atlantic, South Central, and Northern Plains states.

Dollar depreciation by industry

The first step in gauging the response of production in a given industry to an exchange depreciation is to measure the size of the depreciation that has occurred for that industry. In this section, industry-specific measures are described for the amount by which the dollar has depreciated since early 1985. This was developed by weighting inflation-adjusted movements in the exchange rates of U.S. trading partners by their shares of U.S. trade in the particular industry group.

The recent decline in the foreign exchange value of the dollar has not been uniform against individual countries (see Figure 1).[2] For example, the dollar has fallen by roughly one-half against the Japanese yen and the major European currencies. But relative to the Canadian dollar and the currencies of the Pacific Newly Industrialized Countries (PACNIC), the dollar has experienced very little real depreciation. And relative to the currencies of many other Western Hemisphere countries, notably Mexico, the real dollar has, in fact, appreciated significantly.

Because industries differ in their exposure to trade with a particular country, the disparities in dollar depreciation *vis-à-vis* countries imply a difference in the amount of depreci-

Table 1
DEPRECIATION IN REAL VALUE OF THE DOLLAR, BY MANUFACTURING INDUSTRY, MARCH 1985–JUNE 1987

Industry	Decomposition of dollar depreciation, by country group						
	Japan	Europe	Canada	PACNIC	W. Hem.	Other	Total
Food and kindred products	5.94	+14.28	+ 0.64	+ 0.30	− 5.20	+ 1.63	= 17.58
Tobacco	4.55	+23.07	+ .11	+ .53	− 1.54	+ 1.98	= 28.76
Textiles	7.60	+15.27	+ .47	+ .71	− 2.31	+ 1.45	= 23.16
Apparel	1.50	+ 5.98	+ .12	+ 1.89	− 2.17	+ 1.01	= 8.33
Lumber and wood	8.24	+ 4.59	+ 3.09	+ .53	− 1.23	+ .37	= 15.62
Furniture and fixtures	2.35	+14.58	+ 1.50	+ .89	− 1.83	+ .45	= 17.97
Paper	3.85	+10.27	+ 3.36	+ .18	− 2.01	+ .41	= 16.08
Printing and publishing	5.51	+16.30	+ 2.20	+ .30	− 1.14	+ .76	= 23.96
Chemicals	7.01	+19.81	+ .85	+ .33	− 2.71	+ 1.05	= 26.35
Petroleum and coal products	2.30	+12.01	+ .97	+ .24	− 7.67	+ 1.14	= 8.98
Rubber and plastics	8.45	+12.15	+ 1.40	+ .65	− 2.39	+ .52	= 20.77
Leather	.70	+12.11	+ .10	+ 1.72	− 2.61	+ .27	= 12.26
Stone, clay, and glass	7.65	+18.53	+ 1.33	+ .38	− 2.49	+ .29	= 25.70
Primary metals	7.38	+15.12	+ 1.91	+ .15	− 2.54	+ .93	= 22.90
Fabricated metals	8.72	+12.06	+ 1.72	+ .59	− 1.69	+ .50	= 21.91
Nonelectrical machinery	11.72	+18.68	+ .86	+ .38	− 1.66	+ .68	= 30.67
Electronic equipment	17.23	+ 8.20	+ .51	+ .77	− 2.49	+ .56	= 24.80
Transportation equipment	16.48	+11.36	+ 2.16	+ .12	− 1.02	+ .43	= 29.52
Instruments	16.48	+18.53	+ .59	+ .33	− 1.17	+ .62	= 35.39
Miscellaneous manufacturing	4.92	+12.99	+ 1.10	+ .83	− 1.48	+ 1.45	= 19.81

SOURCE: Federal Reserve Bank of Dallas.

ation that has effectively occurred for individual industries. Shown in Table 1 are the calculations for industry-specific measures of the real dollar depreciation since March 1985. The final results are presented in the last column of the table. The middle columns express the final numbers as weighted sums of the country-specific rates of depreciation. The weights for a particular industry reflect the shares of 1986 U.S. bilateral trade in that industry accounted for by the various country groups. By reading down the middle columns, it is possible to determine the industry categories most heavily exposed to trade with a particular country group. For example, electric and electronic equipment is the industry category most heavily exposed to trade with Japan, while apparel is most closely tied to trade with the PACNIC.

The results in Table 1 reveal significant differences in the degree to which individual U.S. industries have been favored by the fall in the dollar. U.S. producers of instruments, nonelectrical machinery, and transportation equipment have enjoyed an effective exchange depreciation of 30-35 percent. This reflects the prominence of Japan and Europe in U.S. trade in these products. For apparel and leather products, on the other hand, the real dollar has fallen by less than 15 percent because these industries are tied much more closely to countries of the PACNIC and the Western Hemisphere.

Responsiveness of domestic production to changes in exchange rates

In assessing the effects of an exchange depreciation on production in a given industry, it is necessary to know not only the amount of depreciation that has occurred for that industry, but also how responsive production is to changes in exchange rates. In the language of the economist, it is necessary to know the exchange rate elasticity of supply. In the present study, the development of these elasticities was based on a simple model of two-way trade in differentiated products. The model was first used to express the exchange rate elasticity of a given industry in terms of a number of basic underlying parameters. Then numerical values obtained for some parameters were used to form an estimate of the elasticity for each U.S. two-digit SIC manufacturing industry.

Consider a particular industry group consisting of two related, but imperfectly substitutable, products. The production of the two goods is assumed to be internationally specialized. One of the goods, identified by the subscript H, is produced under competitive conditions by firms in the home country. The other good, identified by the subscript F, is competitively produced by firms in the rest of the world, collectively expressed as the foreign country. Each country consumes both goods. Equilibrium requires that prices adjust to equate world demand with world supply in each market.

The model described above can be represented formally by the following two equations:

$$(1) \qquad D_H(P,P^*/E) + D^*_H(PE,P^*) = S_H(P) \quad and$$

$$(2) \qquad D_F(P,P^*/E) + D^*_F(PE,P^*) = S^*_F(P^*),$$

where

D = demand
S = supply, and
$*$ = a foreign variable.

Country demands are written solely in terms of relative prices, with income and scale effects ignored. The four important relative prices are expressed as follows. The home-country relative price of good H is denoted P. The foreign-country relative price of good F is denoted P^*. With E representing the real foreign exchange value of the home currency, the home-country relative price of good F can be expressed as P^*/E, and the foreign-country relative price of good H as PE. With this notation, home-country demands can be written in terms of P and P^*/E and foreign-country demands in terms of PE and P^*. Because their production is specialized, the world supply of good H depends only on P, and the world supply of good F only on P^*.

The model presented above can be used to explain how an autonomous depreciation of the home currency serves to raise production of the home good. The direct effect of a decline in E is an increase in the relative price of good F in the home country and a decrease in the relative price of good H in the foreign country. Consumers worldwide are encouraged to substitute away from good F and towards good H. This, in itself, creates an excess of demand over supply in the market for good H. Of course, the market for good F is also thrown out of equilibrium, with supply there exceeding demand. For that market to clear, P^* must fall. It cannot, however, fall by the full amount of the exchange depreciation. Thus, when account is taken of both the original decline in E and the compensating decline in P^*, the net result is a higher relative price of good F in the home country and, therefore, a greater demand for the home good in the home country. It is also the case that the own-price effect in the foreign demand for good H must outweigh the cross-price effect, causing foreign demand for the home good to be higher than before. Thus, after accounting for the required adjustment in P^*, a decline in E is still seen to generate an excess of demand over supply in the market for the home good. This ensures that the home-country price of good H will rise. And this brings forth an increase in the supply of the home good.

The process of adjustment to an exchange depreciation clearly is a complicated one. By using equations 1 and 2, however, it is possible to uncover the basic economic parameters that jointly determine the eventual response in home production to a change in E. After a number of simplifying assumptions were made, the following relationships were obtained that involved movements in home production and in the exchange rate:[3]

$$(3) \qquad \%\Delta S_H = \varepsilon(\%\Delta P) \quad and$$

$$(4) \quad \%\Delta P = \frac{(t_X\eta + T\sigma) + \left(\dfrac{\eta\sigma}{\varepsilon + \eta}\right)(t_X T^* - t^*_X T)}{(\varepsilon + \eta) + (T\sigma + T^*\sigma)} \; (-\%\Delta E),$$

where

$$(5) \qquad T \equiv t_X(1 - t^*_M) + t_M(1 - t_X) \quad and$$

$$(6) \qquad T^* \equiv t^*_X(1 - t_M) + t^*_M(1 - t^*_X).$$

Equation 3 expresses the percentage change in home production in terms of the percentage change in the relative price of the home good. The term ε is the price elasticity of supply. Equations 4-6 link the percentage change in the relative price of the home good to the percentage change in the real exchange rate. The exchange rate elasticity of supply can be obtained by combining equations 3 and 4. This elasticity is seen to depend on several economic parameters: (1) the price elasticity of supply; (2) the price elasticity of demand for the product group, η; (3) the elasticity of substitution between goods within the group, σ; (4) domestic and foreign trade exposure as measured by ratios of exports to production, t_X and t^*_X ; and (5) domestic and foreign trade exposure as measured by ratios of imports to group consumption, t_M and t^*_M.

In numerically evaluating the exchange rate elasticity for each U.S. manufacturing industry, this study has focused on five of the key underlying parameters: the four measures of trade exposure and the degree of substitutability between domestic and foreign products. Values for t_X and t_M were calculated for each industry using 1986 data on U.S. exports and imports and 1985 data on value of shipments. These same data were also used to calculate t^*_X and t^*_M.[4] The values used for σ were taken from the Michigan Model of World Production and Trade.[5]

For the price elasticities of supply and demand, ε and η, the default value of unity was used. This assumption need not seriously distort the relative positions of various industries as determined by their responsiveness to changes in exchange rates. But it clearly reduces the confidence in the absolute values obtained for the exchange rate elasticities. For this reason, the central purpose of the present analysis has been simply to rank individual industries and states by the changes in production expected as a result of the lower dollar.

The numerical values of the key parameters and exchange rate elasticities of supply are shown in Table 2. Over the relevant range of parameter values, the exchange rate elasticities vary directly both with the measures of trade exposure and the substitution elasticity. Thus, the industries found to be the most sensitive to exchange rate movements are miscellaneous manufacturing (including jewelry, toys, and sporting equipment), leather and leather products, transportation equipment, and apparel. These industries are highly exposed to trade, either through exports or imports, and their products are highly substitutable for foreign products within the same product group. Industries such as printing and publishing, food processing, textiles, and tobacco manufacturing are considered relatively insensitive to the exchange rate movements, primarily because of low trade exposure.

Response of U.S. manufacturing to the lower dollar

In this section, the previous results are combined to provide a complete account of the effects of the lower dollar on U.S. manufacturing. Individual industries are ranked according to their expected production responses. The industry figures are then averaged for each of the fifty states, using weights that reflect the importance of each industry in a given state's manufacturing sector. These results are used to identify the states with manufacturing sectors that are likely to respond the most significantly to the lower dollar.

Industry comparisons. For an estimate of the effects of the lower dollar on production in individual manufacturing industries, the industry-specific rates of dollar depreciation (see Table 1) were multiplied by the exchange rate elasticities of supply (see Table 2). The results are shown in Figure 2. As a rule, the production of durable goods is projected to respond more significantly to recent movements in the dollar than is the production of nondurables. The largest percentage gains are shown for transportation equipment and instruments. Each of these industries has enjoyed a real exchange rate depreciation of 30 percent or more. And production in each industry is highly sensitive to exchange rate movements. Other industries with production gains above the mean are miscellaneous manufacturing, electric and electronic equipment, nonelectrical machinery, and chemicals.

The industries expected to respond the least significantly to a lower dollar include lumber and wood products, pulp and paper, textiles, and food processing. For these industries, the recent movements in the dollar have been only moderately favorable, and their production is relatively insensitive to changes in exchange rates.

Although the data in Figure 2 should enhance a general understanding of the future health of U.S. manufacturing, it is of more limited value in explaining recent movements in industrial production or in generating near-term forecasts. For one thing, the estimates presume a complete, long-run response of production to the lower dollar. Temporary labor shortages or constraints on plant capacity play no role in the analysis. In addition, the estimates reveal only the effects of recent movements in the dollar. For some industries, these effects will be dominated by other external factors. The petroleum products industry, for example, is likely

Table 2
CALCULATION OF EXCHANGE RATE ELASTICITIES OF SUPPLY

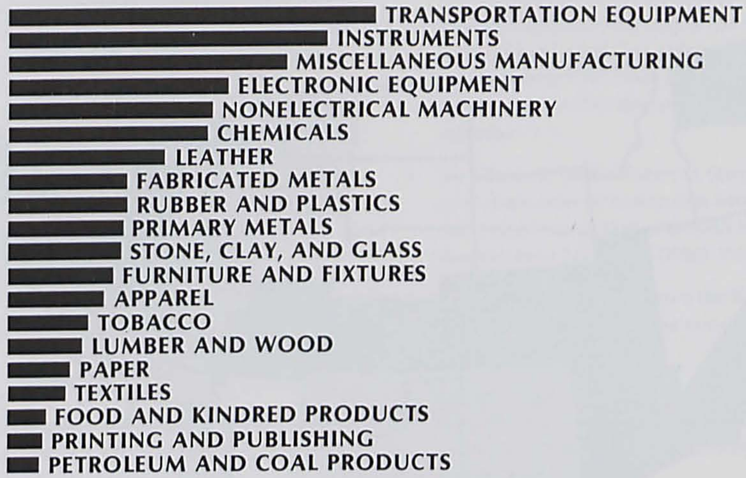
Industry	Measures of trade exposure (percent) t_X	t_M	t^*_X	t^*_M	Substitution parameter	Exchange rate elasticity (Times 10)
Food and kindred products	3.5	5.4	1.8	1.1	1.13	0.62
Tobacco	7.7	.6	.2	2.8	1.13	.79
Textiles	3.0	7.8	2.6	1.0	1.15	.70
Apparel	2.0	25.3	7.8	.5	4.27	3.28
Lumber and wood	5.4	10.0	3.3	1.7	1.76	1.34
Furniture and fixtures	1.4	12.3	3.9	.4	3.10	1.67
Paper	4.7	8.5	2.8	1.5	1.58	1.09
Printing and publishing	1.1	1.4	.5	.4	3.01	.41
Chemicals	11.0	7.5	2.5	3.8	2.61	2.16
Petroleum and coal products	2.3	6.6	2.2	.7	2.36	1.01
Rubber and plastics	4.0	7.8	2.6	1.3	3.21	1.63
Leather	5.9	52.8	15.1	1.0	2.36	3.65
Stone, clay, and glass	3.1	9.2	3.0	1.0	2.26	1.27
Primary metals	4.3	17.9	5.7	1.2	1.44	1.44
Fabricated metals	3.4	6.3	2.1	1.1	3.67	1.55
Nonelectrical machinery	15.4	17.9	5.9	5.0	1.02	1.90
Electronic equipment	10.9	20.6	6.6	3.2	2.11	2.54
Transportation equipment	11.7	23.3	7.4	3.4	3.59	3.57
Instruments	14.5	17.4	5.7	4.7	1.98	2.58
Miscellaneous manufacturing	29.0	41.4	13.0	8.0	1.98	4.03

SOURCE: Federal Reserve Bank of Dallas.

to be affected more by the recent plunge in oil prices than by the lower dollar. As another example, domestic textile manufacturers are not likely to be significantly affected by the fall in the dollar, but they may derive substantial benefits from a more comprehensive and better enforced system of import quotas.

State comparisons. To calculate the effects of the lower dollar on the general level of manufacturing production in a particular state, the individual industry responses were averaged. Used in the calculations were weights that reflect the importance of the various industries to the state's manufacturing sector.[6] This was carried out for each of the fifty states, using 1982 Census data on value added by industry and state (see Figure 3). In the figure, states showing a high response have percentage gains in manufacturing output estimated to be at least 110 percent of the national

Figure 2
Response of U.S. Manufacturing to the Lower Dollar



SOURCE: Federal Reserve Bank of Dallas.

average. States with a medium-high response show gains of 100-110 percent of the national average. States showing a medium-low response reflect gains of 90-100 percent of the national average. Finally, states with a low response show estimated gains in output below 90 percent of the national average.

Significant regional disparities exist in the projected effects of the lower dollar. These differences stem directly from variations in the mix of industries in each state's manufacturing sector. States projected to benefit the most have a large contingent of industries most favored by the fall in the dollar. Thus, Michigan prospers because of the prominence of transportation equipment in its manufacturing, Massachusetts rates high because of its electronic equipment and nonelectrical machinery industries, and California benefits from being an important producer of electronic equipment and transportation equipment.

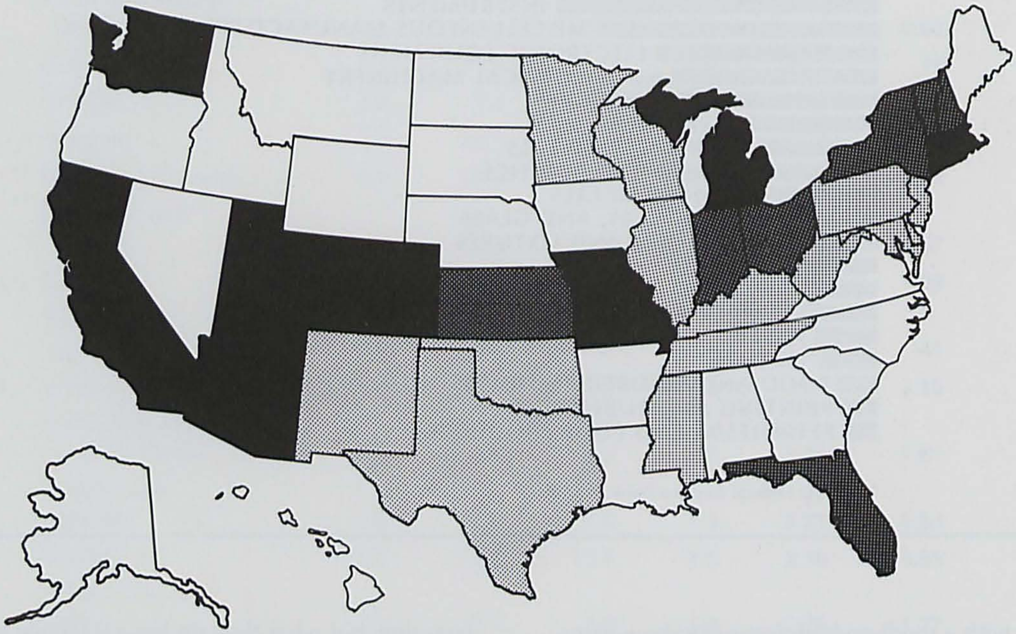
Conversely, states expected to benefit the least have a heavy representation of industries least favored by recent movements in the dollar. The Southern Atlantic states, for example, are relatively well endowed with tobacco, textile, and apparel manufacturing. But these industries are not expected to benefit significantly from the drop in the dollar. States in the Northern Plains not only have very little manufacturing, but what they do have is largely food processing—an industry that is relatively insensitive to exchange rate movements.

Interpretation of the results in Figure 3 should be made with caution. The analysis here has distinguished states only on the basis of the gains expected in their manufacturing sectors. The analysis has ignored other trade-sensitive sectors—such as agriculture and mining—that are also likely to be affected by the decline in the dollar.[7] The conclusions reached here in examining state manufacturing need not carry over to broader measures of state product.

Summary and conclusions

Declines in the value of the dollar, both recent and prospective, will provide a stimulus to U.S. manufacturing on through this decade. The production responses from individual industries will not, however, be uniform. There are two reasons for this. First, recent movements in the dollar have enhanced the competitive position of some industries more than others; second, industries differ in their sensitivity to exchange rate changes. When these two factors are combined—effective dollar depreciation and exchange rate sensitivity—the effects of the lower dollar appear more sig-

Figure 3
Response of State Manufacturing to the Lower Dollar



SOURCE: Federal Reserve Bank of Dallas.

nificant for durable goods manufacturing than for nondurable manufacturing.

Because the industry composition of manufacturing varies across the fifty states, the effects of the lower dollar are also likely to be uneven across geographic regions. Based on this study, manufacturing production in much of the Northeast, Upper Midwest, and West is projected to rise at a rate that exceeds the national average. The findings also show, however, that below-average gains in production are projected for most of the Southern Atlantic, South Central, and Northern Plains states.

1. This is based on the RX-101 Dollar Index, which is maintained and published by the Federal Reserve Bank of Dallas (see W. Michael Cox, "A Comprehensive New Real Dollar Exchange Rate Index," *Economic Review*, Federal Reserve Bank of Dallas, March 1987, 1-14). Exchange rate changes cited in subsequent sections of the paper are based upon indexes more specifically designed to reflect conditions in U.S. manufacturing.

2. The rates of dollar depreciation indicated for various country groups are weighted averages of the inflation-adjusted movements in the dollar *vis-à-vis* the currencies of individual member countries. The definition of country groups, as used in this study, can be found in Cox, "A Comprehensive New Real Dollar Exchange Rate Index," 11. The weight for the *i*th member of the *j*th group is the ratio of total U.S. bilateral trade in manufactured products with country *i* during 1986 to total U.S. bilateral trade in manufactured products with all countries in group *j* during 1986. Inflation adjustments were made using consumer price indexes. For a defense of this choice of price index, see Cox, "A Comprehensive New Real Dollar Exchange Rate Index," 3.

3. Details of the derivation are available from the authors upon request. The following assumptions were used to simplify the solution:

- Goods H and F are equally substitutable for goods outside the industry group. The sum of the own-price and cross-price elasticities of demand are then the same for each good and can be interpreted as the price elasticity of group demand.

- The utility functions of consumers and production functions of producers are weakly separable in the product group. This implies that the cross-price elasticities of demand for goods H and F can be expressed in terms of the share of group expenditures allocated to imports and an elasticity of substitution which holds constant the value of a subutility or subproduct function.

- The home and foreign countries have the same price elasticity of group demand, the same price elasticity of supply, and the same elasticity of product substitution.

4. For any given manufacturing industry, let S_H = U.S. production, X = U.S. exports, M = U.S. imports, and r = the ratio of foreign to U.S. demand. Then the measures of foreign trade exposure can be written as

$$t^*_X = M/[rS_H + (1+r)(M-X)] \quad \text{and}$$

$$t^*_M = X/[rS_H + r(M-X)].$$

In computing t^*_X and t^*_M, industry-specific data were used for S_H, X, and M, as noted above. Because of data limitations, however, the term r was assumed to be the same for each manufacturing industry.

The specific value used for r was developed in the following way. In 1980, the United States accounted for 25 percent of world manufacturing output (see International Monetary Fund, *International Financial Statistics: Supplement on Output Statistics*, Supplement Series no. 8 [Washington, D.C., 1984]), and the U.S. trade deficit in manufactured products was small in relation to total U.S. production of manufactured goods. Thus, the United States also accounted for roughly 25 percent of world manufacturing demand in 1980. Since that time, the U.S. share of world manufacturing output has fallen, but the U.S. trade deficit in manufactured goods has widened considerably. It is reasonable, then, to assume that the United States continues to account for about one-fourth of the world's demand for manufactured products. The implied value for r is 3.

5. See Clinton R. Shiells, Robert M. Stern, and Alan V. Deardorff, "Estimates of the Elasticities of Substitution between Imports and Home Goods for the United States," *Weltwirtschaftliches Archiv (Review of World Economics)*, Band 122, Heft 3 (1986): 515.

6. This, of course, abstracts from the likely possibility that new investment will not be distributed in the same way as the initial distribution of manufacturing output.

7. For an analysis of the relationship between the value of the dollar and the price of oil, see Stephen P. A. Brown and Keith R. Phillips, "Exchange Rates and World Oil Prices," *Economic Review*, Federal Reserve Bank of Dallas, March 1986, 1-10.

The Effect of Monetary Policy on Long-Term Interest Rates: Further Evidence from an Efficient-Markets Approach

Kenneth J. Robinson

Economist
Federal Reserve Bank of Dallas

The degree to which monetary policy affects interest rates has important macroeconomic implications. In the transmission mechanism of many large-scale econometric models, a key feature is the so-called liquidity effect—the temporary decline in both short-term and long-term interest rates brought about by an expansionary monetary policy.[1] In addition, the belief that the central bank can affect interest rates through its policy actions may result in widespread requests to guide monetary policy toward the aim of influencing interest rates.

Early work on the effect of monetary policy on interest rates centered on reduced-form estimates of the impact of past money growth on interest rates. A significant liquidity effect was discovered, with the response time varying from four to nine months up to two years.[2] Subsequent research, using the same reduced-form approach and covering mostly the period of the 1970s and early 1980s, finds either a rapidly vanishing liquidity effect or no significant movement at all in short-term interest rates in response to monetary stimulus. Market participants' increasing sensitivity to the inflationary consequences of an expansionary monetary policy is cited as a prime factor behind the absence of a liquidity effect during this period.[3]

The view of a liquidity effect as a key element in the transmission mechanism of monetary policy has been subject to criticism on both theoretical and empirical grounds. The theoretical critique basically acknowledges the possibility of a liquidity effect but also hypothesizes that monetary expansion could ultimately lead to higher interest rates.[4] The rise in interest rates comes about through the expansionary effect that increases in the money supply exert on both income and prices. An acceleration in both of these variables would tend to increase money demand, leading to upward pressures on interest rates. Further, in-

The author would like to thank W. Michael Cox and Cara S. Lown for the use of their data on the holding-period rate of return for government bonds. He would also like to thank Jeffery W. Gunther for helpful comments and discussions.

creases in the money supply could influence inflationary expectations and ultimately lead to higher interest rates. On empirical grounds, criticism of previous research on the search for a liquidity effect focuses on the reduced-form approach itself. Regressing changes in interest rates on distributed lags of past money growth is an *ad hoc* procedure devoid of any theoretical structure. Interpretation of the parameter estimates from such a procedure is often difficult because of the lack of a formal framework in which to analyze the results.

In an effort to remedy these shortcomings, additional research has made use of a rational expectations-efficient markets framework in which to analyze the effects of monetary growth on interest rates. With such an approach, monetary policy is found to have no significant influence on either short-term or long-term interest rates in a period covering up to the mid-1970s.[5] Moreover, in the estimation procedure, it can be shown that failure to assume that expectations are formed rationally can give rise to misleading results.[6]

This article makes use of a model incorporating market efficiency to update the impact of monetary policy on long-term interest rates, using monthly data over the 1959-86 period.[7] The empirical results indicate the absence of a liquidity effect over the entire sample period. In fact, contrary to previous results, an expansionary monetary policy is found to be associated with a rise in long-term interest rates. Estimates for various subperiods reveal that in the decade of the 1980s, in particular, this relationship appears to have emerged. These results cast doubt on the ability of an expansionary monetary policy to lower long-term interest rates significantly. Repeated demands on the central bank for an easy monetary policy, with the aim of keeping interest rates low, should be viewed with skepticism.

The analysis here proceeds as follows. The model is described in the next section. The third section contains an explanation of the estimation technique, and the fourth section offers an interpretation of the empirical results. The last section sets forth the conclusions.

The rational expectations-efficient markets model

The theory of rational expectations, or what is known in finance as the efficient-markets theory, states that prices of financial assets should reflect all available information. More formally, in a rational expectations framework the market's subjective probability distribution of any variable is identical to the objective probability distribution of that variable, conditional on all available information.

Market efficiency is especially appealing because it implies that no unexploited profit opportunities exist in securities markets. That is, at the current price, market participants cannot expect to earn a higher than normal rate of return by investing in any particular security. In essence, market efficiency implies an arbitrage condition. When arbitrageurs who are willing to speculate perceive unexploited profit opportunities, they buy or sell securities to the point where the efficient-markets condition holds.

In order to give this efficient-markets condition empirical content, a model of the equilibrium return for a security must be specified. In the model used in this study, the market is assumed to equate expected one-period holding returns across securities. The risk or liquidity premium in this model is assumed to be constant over time.[8] For long-term bonds, then, the equilibrium holding-period rate of return ($\underline{HPRR_t}$) from period $t-1$ to t includes interest payments plus capital gains and is given as

$$(1) \qquad \underline{HPRR_t} = E_m(HPRR_t \mid \phi_{t-1}) = r_{t-1} + \delta,$$

where

$\underline{HPRR_t}$ = the equilibrium, or expected, holding-period rate of return;
E_m = expectation assessed by the market;
$HPRR_t$ = the actual holding-period rate of return;
ϕ_{t-1} = information set available at time $t-1$;
r_{t-1} = the one-period (short-term) interest rate at time $t-1$, which equals the yield to maturity or the expected one-period, short-term return; and
δ = (constant) liquidity or risk premium.

Market efficiency, then, implies that

$$(2) \quad E_m(HPRR_t - \underline{HPRR_t} \mid \phi_{t-1}) = E_m(HPRR_t - r_{t-1} - \delta \mid \phi_{t-1}) = 0.$$

According to equation 2, no unexploited profit opportunities exist. Market participants cannot expect to earn a higher than normal rate of return by investing in a long-term bond.[9] From this efficient-markets or arbitrage condition, it follows that unanticipated changes in interest rates ($HPRR_t - r_{t-1}$) should be uncorrelated with any past available information. In an efficient-markets framework, it is only when new information hits the market that *ex post* rates of return would differ from *ex ante* rates. More formally, it might be hypothesized that

$$(3) \qquad (HPRR_t - r_{t-1}) = \delta + \beta(X_t - X_t^e),$$

where X_t is a vector of variables relevant to the pricing of long-term bonds and X_t^e is the market's anticipations of these variables.

In the search for a liquidity effect, one choice to include in the X_t vector is money growth. Following the liquidity preference approach to money demand, other factors might also be important in affecting the price of long-term bonds, and thus their rate of return, including income growth and inflation.[10] Incorporating these three variables into equation 3 yields the following:

$$(4.1)\quad (HPRR_t - r_{t-1}) = \beta_0 + \beta_1(MG_t - MG_t^e) + \varepsilon_t$$

and

$$(4.2)\quad (HPRR_t - r_{t-1}) = \beta_0 + \beta_1(MG_t - MG_t^e) + \beta_2(YG_t - YG_t^e) + \beta_3(INF_t - INF_t^e) + \varepsilon_t,$$

where *MG* is money growth; *YG* is the growth rate of national income; *INF* is the rate of inflation; MG^e, YG^e, and INF^e are the market's anticipations of *MG*, *YG*, and *INF*, respectively; and ε_t is a white-noise error term.

If a liquidity effect is present, then the coefficient on unanticipated money growth should be positive. That is, if an unexpected increase in the money supply lowers long-term interest rates, the holding-period rate of return increases. From a liquidity preference view, the coefficients on unanticipated income growth and unanticipated inflation should be negative. Unanticipated increases in income growth and inflation are hypothesized to raise interest rates and, thus, lower holding-period rates of return.

One note of caution is in order regarding the estimation procedure used in this study. The efficient-markets approach does not guarantee that the independent variables of equations 4.1 and 4.2 are exogenous. In this framework, causation is hypothesized to run only from unanticipated variables affecting interest rate movements. The efficient-markets theory does not, however, rule out the possibility that interest rate movements may affect money growth. The fact that simultaneity problems in an efficient-markets model cannot be ruled out could result in inconsistent parameter estimates.[11]

Estimation procedure

Data for $HPRR_t$—in this study, the holding-period rate of return on long-term U.S. Government bonds—were obtained from the series on the market value of government debt that has been calculated by Cox and Lown.[12] This measure includes both interest payments and capital gains or losses. The variable r_{t-1} is the three-month U.S. Treasury bill rate.

Expectations of money growth, growth in income, and inflation are assumed to be rational forecasts obtained from linear forecast equations. Economic theory may not be a very useful guide in deciding exactly what information economic agents use in the formation of expectations of these variables. Therefore, multivariate forecast equations are derived, making use of the Granger concept of predictive content.[13] Monthly data for the 1959-86 period are employed for the following variables:

$M1G$ = growth rate (first difference in logs) of M1,
$M2G$ = growth rate (first difference in logs) of M2,
IPG = growth rate (first difference in logs) of industrial production—as a proxy for growth in national income, and
INF = growth rate (first difference in logs) of the consumer price index.

Both the M1 and M2 monetary aggregates are used in an effort to determine how sensitive the results are to different measures of the money supply.

Table 1
VARIABLES SIGNIFICANT IN FORECAST EQUATIONS USED IN FORMING EXPECTATIONS

Equation, variable	*F* statistic	B-G	L-B
M1G equation		0.77	17.31
M1G	5.320*		
M2G	1.934**		
IPG	2.017**		
INF	2.190*		
TBILL	5.410*		
MDEF	2.230*		
M2G equation		0.03	17.39
M1G	2.430*		
M2G	16.070*		
TBILL	5.280*		
MDEF	2.170*		
IPG equation		4.63	14.86
M2G	2.230*		
IPG	2.790*		
INF	2.970*		
INF equation		0.10	12.07
INF	37.960*		
TBILL	2.000**		
MDEF	2.110*		

* Significant at the 1-percent level.
** Significant at the 5-percent level.
NOTE: B-G = Breusch-Godfrey test statistic.
L-B = Ljung-Box test statistic.

Table 2
ESTIMATED EFFECTS OF UNANTICIPATED VARIABLE CHANGES ON LONG-TERM INTEREST RATES, 1959-1986

	Coefficients of					
Constant	$(M1G - M1G^e)$	$(M2G - M2G^e)$	$(IPG - IPG^e)$	$(INF - INF^e)$	R^2	B-G
.0534** (.0238)	-18.4125** (8.1484)				.03	.03
.5332* (.0224)	-15.8687 (8.2158)		-7.9383* (2.8162)	-20.7271 (11.9177)	.05	.03
.5340** (.0231)		-44.2181* (11.5678)			.06	.03
.0533* (.0219)		-40.7341* (11.5936)	-6.9362* (2.7285)	-21.6227 (11.6020)	.08	.06

* Significant at the 1-percent level.
** Significant at the 5-percent level.
NOTE: B-G = Breusch-Godfrey test statistic.
Figures in parentheses are standard errors.

In deriving the forecast equations, each of the four variables just listed was regressed on its past values, plus lagged values of the other three variables, plus lags of each of the following variables:

URATE = unemployment rate,
TBILL = three-month Treasury bill rate,
FEDG = growth rate of real Federal Government expenditures, and
MDEF = growth rate of Federal Government interest-bearing debt in the hands of the public.

Both *FEDG* and *MDEF* were interpolated to monthly data by using the Chow-Lin procedure.[14] These additional variables are included because they are often found to be important determinants of Federal Reserve behavior and, thus, would be primary candidates for inclusion in the information set used by economic agents.[15]

In order to reduce the residuals of the forecast equations to white noise, it was necessary to use 12 lags of each variable. In each forecast equation, a variable was retained only if its 12 lags were jointly significant. The variables that were found to be statistically significant appear in Table 1. The respective *F* values reported correspond to the value of the *F* statistic used to test the hypothesis that, jointly, the coefficients on the 12 lags of a particular variable are insignificantly different from zero. Since the Durbin-Watson statistic is invalid because of the presence of lagged dependent variables, the Breusch and Godfrey (B-G) test statistic is reported to detect the presence of serial correlation. Further, the Ljung-Box (L-B) statistic, which tests the hypothesis that the residuals are white noise, is included. Both the B-G and L-B statistics indicate that the forecast equations contain white-noise residuals.[16]

In addition to requiring white-noise residuals, the forecast equations should also be stable. Chow tests were conducted on each equation for instability, both at the midpoint of the time series and in October 1979. The latter point was chosen because the change in Federal Reserve operating procedures undertaken at that time might have altered the manner in which agents formed expectations.[17] These Chow tests indicated no structural change at the midpoint of the data but did indicate that a change occurred in 1979 for the *M1G*, *M2G*, and *INF* equations. To account for this instability, therefore, the forecast equations for the three variables were estimated separately for the periods before and after October 1979.

The parameters of equations 4.1 and 4.2 were estimated with the two-step procedure that entails using the residuals from the forecast equations as independent variables.[18] The procedure results in consistent parameter estimates but implicitly assumes no uncertainty in the estimates of the coefficients of the forecast equations. The implication is that any potential measurement error in the independent variables of equations 4.1 and 4.2 would be ignored, possibly resulting in incorrect estimates of the standard errors. To resolve this problem, the method developed by Murphy

Table 3
ESTIMATED EFFECTS OF UNANTICIPATED VARIABLE CHANGES ON LONG-TERM INTEREST RATES IN SELECTED PERIODS

	Coefficients of					
Constant	$(M1G - M1G^e)$	$(M2G - M2G^e)$	$(IPG - IPG^e)$	$(INF - INF^e)$	R^2	B-G
			1959-69			
-.0022	4.2541				.080	0.484
(.0102)	(4.4716)					
-.0029	4.5760		-1.2540	-12.7423	.040	0.236
(.0102)	(4.5951)		(1.5230)	(8.3297)		
-.0020		4.8568			.002	0.637
(.0102)		(8.6353)				
-.0028		5.8250	-1.0761	-12.8697	.030	0.366
(.0103)		(8.7300)	(1.5170)	(7.4702)		
			1970-79			
.0164	-4.6886				.004	0.012
(.0176)	(6.5322)					
.0160	-4.9625		-3.2296	-1.1787	.020	0.024
(.0177)	(6.5655)		(2.3339)	(10.1598)		
.0167		-7.4715			.004	0.002
(.0176)		(10.5466)				
.0163		-5.5130	-2.9925	-1.5841	.020	0.012
(.0177)		(10.6783)	(2.3467)	(10.1189)		
			1980-86			
.1855*	-104.5332*				.110	1.130
(.0672)	(32.8280)					
.1703*	-77.1513*		-25.2810*	-51.0911	.200	0.066
(.0647)	(32.0610)		(11.9236)	(41.1511)		
.1855*		-105.2110*			.130	0.456
(.0665)		(30.3457)				
.1715*		-90.4101*	-23.3364*	-58.4017	.230	0.224
(.0635)		(30.5373)	(10.1185)	(36.1082)		

* Significant at the 1-percent level.
NOTE: B-G = Breusch-Godfrey test statistic.
Figures in parentheses are standard errors.

and Topel was used to obtain the asymptotically correct covariance matrix.[19]

Empirical results

Estimates of the parameters of equations 4.1 and 4.2 are found in Tables 2 and 3. Table 2 shows parameter estimates for the models, corrected for serial correlation, over the entire sample period, 1959-86. The results indicate that no liquidity effect is present regardless of which monetary aggregate is used. In fact, the coefficients on unanticipated money growth are significantly negative in all but one of the models estimated in Table 2. Unexpected money growth has a significant positive correlation with long-term interest rates. The broader monetary aggregate appears to have a stronger influence on interest rate movements than M1 does, perhaps because the range of financial assets included in M2 is more extensive. Unanticipated industrial production growth has its hypothesized sign, while unanticipated inflation is not a significant factor affecting interest rates. The low values of the coefficients of determination are not surprising in light of the fact that the dependent variable, in effect, is a forecast error.

In an effort to determine whether the response of interest rates to changes in monetary policy has varied over the years, equations 4.1 and 4.2 were estimated for various periods. The results of estimating the model for the decades of the 1960s and 1970s and for 1980-86 are found in Table 3. For the relatively tranquil 1960s, the model performs poorly; none of the variables are significant. In the 1970s the coefficient on unanticipated money growth becomes negative but is not statistically significant. In both the 1960s and the 1970s, the coefficients on unanticipated industrial production growth and unanticipated inflation have their hypothesized signs but are insignificantly different from zero. It is in the 1980s that unanticipated money growth has a significant effect on interest rates, but one in the opposite direction from that implied by the liquidity effect. Unexpected increases in the growth rate of money result in increases in long-term interest rates.

One possible explanation for this response pattern of interest rates is that following the inflation-ridden decade of the 1970s, market participants became more responsive to monetary policy. This is in line with Mishkin's point about the possible short-run effects of an expansionary monetary policy on nominal interest rates. "More importantly for short-run effects on interest rates, increases in the money stock could also influence anticipations of inflation. Higher expected inflation resulting from money stock increases would, through a Fisherian . . . relation, increase nominal interest rates."[20]

The results from the analysis here indicate that the belief that an easy monetary policy is capable of lowering long-term interest rates should be viewed with skepticism. Repeated calls for the central bank to "ease up," with the aim of encouraging a fall in interest rates, are likely to be met with disappointment. Moreover, in structural macro models, the traditional mechanism that emphasizes the effects of monetary policy on long-term interest rates and the cost of capital can be questioned. Changes in the cost of capital are hypothesized to alter the spending plans of both businesses and consumers. The evidence provided in this study indicates that these hypothesized real effects from monetary expansion might not be forthcoming.

Conclusion

A key feature in the transmission mechanism of many large-scale econometric models is the decline in long-term interest rates associated with an expansionary monetary policy. The existence of this so-called liquidity effect has been challenged recently. Earlier reduced-form work found a significant liquidity effect, but subsequent research finds a rapidly vanishing liquidity effect or no significant interest rate response at all.

Using a rational expectations-efficient markets framework, the analysis here has extended previous research and discovered an effect on long-term interest rates opposite to that associated with a liquidity effect. In particular, it appears to be the case that market participants, after being battered by the macroeconomic turbulence of the 1970s, have become more responsive to the possibly adverse effects an expansionary monetary policy might exert on the economy.

---

1. See Frederic S. Mishkin, "Efficient-Markets Theory: Implications for Monetary Policy," *Brookings Papers on Economic Activity*, 1978, no. 3: 707-52, for a discussion of the transmission mechanism.

2. See Phillip Cagan and Arthur Gandolfi, "The Lag in Monetary Policy as Implied by the Time Pattern of Monetary Effects on Interest Rates," *American Economic Review* 59 (May 1969, Papers and Proceedings, 1968): 277-84; William E. Gibson, "Interest Rates and Monetary Policy," *Journal of Political Economy* 78 (May/June 1970): 431-55; and Phillip Cagan, *The Channels of Monetary Effects on Interest Rates* (New York: National Bureau of Economic Research, 1972).

3. See Michael Melvin, "The Vanishing Liquidity Effect of Money on Interest: Analysis and Implications for Policy," *Economic Inquiry* 21 (April 1983): 188-202; and William Reichenstein, "The Impact of Money on Short-Term Interest Rates," *Economic Inquiry* 25 (January 1987): 67-82.

4. Milton Friedman, "The Role of Monetary Policy," *American Economic Review* 58 (March 1968): 1-17.

5. Frederic S. Mishkin, "Monetary Policy and Long-Term Interest Rates: An Efficient Markets Approach," *Journal of Monetary Economics* 7 (January 1981): 29-55; and Frederic S. Mishkin, *A Rational Expectations Approach to Macroeconometrics: Testing Policy Ineffectiveness and Efficient-Markets Models* (Chicago: University of Chicago Press, 1983).

6. See Mishkin, "Efficient-Markets Theory," for a discussion of the consequences resulting from a failure to incorporate market efficiency.

7. For an analysis of the effects on short-term interest rates in an efficient-markets model, see Reichenstein, "The Impact of Money on Short-Term Interest Rates," and Kenneth J. Robinson and Eugenie D. Short, "Estimating the Impact of Monetary Policy on Short-Term Interest Rates in a Rational Expectations-Efficient Markets Model: Further Evidence," Federal Reserve Bank of Dallas Research Paper no. 8801 (Dallas, February 1988).

8. This approach was also used in Eugene F. Fama and G. William Schwert, "Asset Returns and Inflation," *Journal of Financial Economics* 5 (November 1977): 115-46, and in Mishkin, "Monetary Policy and Long-Term Interest Rates."

9. This efficient-markets model is consistent with the expectations hypothesis of the term structure. This hypothesis states that the long-term

interest rate at time t, RL_t, is an average of expected future short-term rates plus a liquidity premium:

$$RL_t = \delta + (1/n)E_m(r_t + r_{t+1} + \ldots + r_{t+n-1}).$$

If expectations of future short-term rates are formed rationally, the expectations hypothesis of the term structure yields the same implications as equation 2. See Franco Modigliani and Robert J. Shiller, "Inflation, Rational Expectations and the Term Structure of Interest Rates," *Economica* 40 (February 1973): 12-43.

10. See David E. W. Laidler, *The Demand for Money: Theories, Evidence, and Problems*, 3d ed. (New York: Harper & Row, 1985).

11. The money supply process may be endogenous, as pointed out in Robert G. King and Charles I. Plosser, "Money, Credit, and Prices in a Real Business Cycle," *American Economic Review* 74 (June 1984): 363-80. Current unanticipated money growth is, by construction, uncorrelated with previously unexpected changes in interest rates. The assumption here is that unanticipated movements in interest rates this period do not affect current unanticipated money growth. No evidence is presented regarding the exogeneity of the independent variables. If endogeneity is a problem, the coefficient estimates can then be viewed as providing information about the correlation of unanticipated movements in the right-hand-side variables and movements in interest rates.

12. W. Michael Cox and Cara S. Lown, "The Capital Gains and Losses on U.S. Government Debt: 1942-1986," Federal Reserve Bank of Dallas Research Paper no. 8705 (Dallas, July 1987).

13. C. W. J. Granger, "Investigating Causal Relations by Econometric Models and Cross-spectral Methods," *Econometrica* 37 (July 1969): 424-38

14. Gregory C. Chow and An-loh Lin, "Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Time Series by Related Series," *Review of Economics and Statistics* 53 (November 1971): 372-75.

15. See James Barth, Robin Sickles, and Philip Wiest, "Assessing the Impact of Varying Economic Conditions on Federal Reserve Behavior," *Journal of Macroeconomics* 4 (Winter 1982): 47-70, and the references cited therein for a review of the reaction function literature.

16. T. S. Breusch, "Testing for Autocorrelation in Dynamic Linear Models," *Australian Economic Papers* 17 (December 1978): 334-55; L. G. Godfrey, "Testing for Higher Order Serial Correlation in Regression Equations When the Regressors Include Lagged Dependent Variables," *Econometrica* 46 (November 1978): 1303-10; and G. M. Ljung and G. E. P. Box, "On a Measure of Lack of Fit in Time Series Models," *Biometrika* 65, no. 2 (1978): 297-303. The B-G statistic is used because it can also test for higher-order serial correlation. While not discussed here, tests conducted for second-, third-, and fourth-order autocorrelation indicate an absence of higher-order autocorrelated error terms. The Ljung-Box statistic reported is a modification of the Box-Pierce "*Q*" statistic, which tests for white noise. This variation on the Q statistic is used because Ljung and Box find, in a series of Monte Carlo experiments, that it more closely approximates the chi-square distribution in small samples.

17. For a description of this change in Federal Reserve operating procedures, see Marvin Goodfriend and William Whelpley, "Federal Funds: Instrument of Federal Reserve Policy," Federal Reserve Bank of Richmond *Economic Review*, September/October 1986, 3-11. Use of the Chow test assumes both that the hypothesized break point is known and that the change in regimes is abrupt. Further, it is also necessary to assume that the error variances are the same across regimes.

18. The two-step procedure was used initially in Robert J. Barro, "Unanticipated Money Growth and Unemployment in the United States," *American Economic Review* 67 (March 1977): 101-15.

19. Kevin M. Murphy and Robert H. Topel, "Estimation and Inference in Two-Step Econometric Models," *Journal of Business & Economic Statistics* 3 (October 1985): 370-79.

20. Mishkin, "Monetary Policy and Long-Term Interest Rates," 30.