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In This Issue . . .

In the first article in this *Review*, "Is Money Irrelevant?" Gerald P. Dwyer, Jr. and R. W. Hafer examine whether the stock of money in the economy is largely irrelevant for the future path of important macroeconomic measures, such as inflation, income and real output. Long-standing propositions suggest that changes in money growth affect the long-run rate of increase of variables such as nominal GNP and the price level but do not affect the long-run rate of increase of real GNP. In particular, an increase in the annual growth of money by one percentage point per year should be associated with a one percentage point increase in the rate of increase of nominal GNP and the price level. Basic economic theory, however, provides some reasons why these relationships do not hold exactly over short periods of time. Dwyer and Hafer examine these propositions using data across 62 countries from 1979 to 1984, using the five-year period to examine the long-run effects and two individual years, 1979 and 1984, to see whether the relationships actually are looser over shorter periods.

The authors find a clear one-for-one association of the money stock with nominal GNP and the price level for the five-year period. In any given year, though, the association of the money stock with nominal GNP and the price level is weak at best. In no case, however, do they find evidence of a reliable relationship between money and real GNP. The authors conclude that attempts to use the long-run relationships to explain the data over short periods are quite likely to be disappointing. Furthermore, such attempts may produce misleading conclusions about the importance of the money stock in influencing nominal GNP and the price level.

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Recently, a number of official investigating agencies have released reports about the October 1987 crash in stock prices. The report of the Presidential Task Force on Market Mechanisms (the Brady Commission) has received the most public attention; the legislative and regulatory stock market reforms that have been proposed recently are based primarily on its recommendations.

The Brady report suggests that the interaction of index arbitrage and portfolio insurance trading strategies caused a "downward cascade" in stock prices on October 19. In the second article in this *Review*, "The October Crash: Some Evidence on the Cascade Theory," G. J. Santoni analyzes this claim using minute-by-minute data on the prices of stocks from October 15 to October 23, 1987. Santoni notes that the cascade theory advanced in the Brady report relies on notions that stock traders behave mechanically, are insensitive to price and execute trades without regard to transaction costs. However, not only are these notions inconsistent with economic theory, the data analyzed by Santoni do not support the view that the trading strategies caused the crash in stock prices. History, the author argues, indicates that legislative reforms following a financial panic have done little to reduce the frequency or severity of subsequent panics. Santoni concludes that the reforms advanced by the proponents of the cascade theory are unlikely to alter this historical pattern.

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The internationalization of the U.S. economy has forced state governments to become increasingly aware of the importance of international business activity in sustaining the level and growth of economic activity in their own states. In recent years, state governments have devoted more resources to promote manufactured exports by firms located within their states.

Previous research indicates a positive relationship between exports from a state and its promotional expenditures. In the third article in this *Review*, "The Competitive Nature of State Spending on the Promotion of Manufacturing Exports," Cletus C. Coughlin examines the related issue of whether a state's exports are affected by the promotional expenditures of other states. The author finds some evidence that exports from one state are affected negatively by the promotional expenditures of other states; however, data limitations and the sensitivity of results to different measures of promotional expenditures by other states preclude a definitive conclusion.

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In 1973, the Swiss National Bank ceased pegging the exchange rate of the Swiss franc to the U.S. dollar. Since then, the monetary authority has focused on reducing inflation. Money demand estimates help to gauge the effect of monetary growth on inflation. Hence, they are important in the formulation of monetary targets in Switzerland.

In the fourth article in this issue, "Money Demand and Inflation in Switzerland: An Application of the Pascal Lag Technique," Tobias F. Rötheli develops a flexible model of price-level adjustment to estimate Swiss money demand. This econometric specification allows the estimation of money demand elasticities and the dynamic response of the price level to a change in the supply of or demand for real money balances. The results corroborate the skepticism toward the use of the partial-adjustment hypothesis or Koyck lag for the price-level adjustment: it takes approximately one and one-half years for the adjustment speed of the price level to reach its maximum. Moreover, the Koyck lag overestimates the half-time of the price-level adjustment by 90 percent. Additional findings on the demand for money indicate that, if no structural shifts occur, M1 growth of between 1 percent and 3 percent per year is consistent with a stable price level in Switzerland.

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In the final article in the *Review*, Daniel L. Thornton investigates the responsiveness of interest rates to changes in monetary policy. Analysts often argue, Thornton notes, that changes in monetary policy initially affect the economy through a "liquidity effect" on interest rates. For example, an expansionary monetary policy is said to depress market interest rates initially. Applying three reduced-form methodologies commonly found in the literature to the same monthly data set, the author finds no evidence of a strong, statistically significant, inverse relationship between monetary changes and interest rates. He finds that the strongest and most consistent negative relationship is between interest rates and nonborrowed reserves. Even in this case, however, the effect is weak and short-lived.

Gerald P. Dwyer, Jr., and R. W. Hafer

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Is Money Irrelevant?

MANY economists recently have been claiming that money has little or no effect on inflation and economic activity. For example, Lyle E. Gramley, past governor of the Federal Reserve Board, has been quoted as saying "the relationship between growth of the economy and the growth of the money supply is just no longer there."[1] Meanwhile, even a noted monetarist such as Beryl W. Sprinkel, the current chairman of the Council of Economic Advisers, says: "It's a problem. Nobody knows where we are going."[2]

These recent statements are hardly novel, nor have they changed all that much over the years. In 1971, Federal Reserve Board Governor Andrew F. Brimmer noted that it has "not [been] demonstrated convincingly that the relationship between the money supply and economic activity is especially close."[3]

The overriding question seems to be how well money growth predicts economic activity over some horizon. In this paper we offer a brief discussion of how changes in the growth of the money supply affect the economy in the long run. Following this, we use cross-sectional data based on a large number of countries to see how well the offered theory holds up to the facts. We also illustrate that the connection between changes in money growth and economic activity is quite loose over short time periods. The upshot of our findings is that, even today, one cannot dismiss the proposition that, in the long run, increases in the growth of the money supply will increase inflation and have no lasting effect on real economic activity.

SOME BASIC PROPOSITIONS

The basic propositions discussed are derived from the quantity theory. Basically, this theory states that, in the long run, changes in money growth are reflected one-for-one in nominal income growth and inflation but have no impact on the output of real goods.[4]

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[1]See Kilborn (1986).

[2]Ibid. Among other things, monetarism is characterized by the proposition that there is a direct and proportional linkage between changes in the growth of the money supply and nominal economic variables, like inflation and nominal income growth. In addition, money growth changes have no influence on real economic activity. The effects on nominal income and inflation hold in the long run, a point discussed later in this article. See Brunner (1968), who coined the term monetarist, for a discussion of these and other issues.

[3]Quoted in Francis (1972).

[4]Many economists who would not call themselves quantity theorists or monetarists probably would subscribe to the following propositions.

Money and Nominal Income

Going back at least to Irving Fisher (1911) and Arthur C. Pigou (1917), the first proposition is:

> ***Proposition I:*** *Changes in the money supply are associated with changes in spending and nominal income.*

This proposition results from an analysis of the demand for and the supply of money, which can be discussed conveniently in terms of the quantity equation,

(1) $M = kY$,

where M is the nominal quantity of money, k is households' and firms' desired ratio of money to income, and Y is nominal income. In the first instance, M can be interpreted as the quantity of money demanded by firms and households. If the amount of money households and firms want to hold relative to income is constant, equation 1 simply says that an increase in nominal income will increase the quantity of money demanded — a plausible statement.[5]

Saying anything about the effects of changes in the money supply on income requires a supposition about the relationship between the quantity of money demanded and supplied. At least over longer periods of time, the quantity of money demanded and the quantity supplied are the same.[6] Under this supposition, equation 1 says that the quantity of money supplied equals households' and firms' desired ratio of money to income multiplied by nominal income. If the quantity of money supplied increases, either k, the desired ratio of money to income, or Y, nominal income, must increase.

What actually happens if the quantity of money in an economy suddenly increases? The additional money will be held: it is a rare person who burns money. Assuming that nominal income and households' and firms' desired ratio of money to income initially are unaffected, firms and households momentarily are holding more money than they want to hold. What will they do? They will spend some of it. To the extent the additional money is spent on final goods and services, Gross National Product (the dollar value of such spending) increases. Because Gross National Product also is a measure of nominal income, an increase in the quantity of money supplied increases both spending and income.

A strong corollary of this first proposition is:

> ***Proposition Ia:*** *An increase in the growth rate of money will be matched by an equal increase in the growth rate of nominal income.*

When the quantity equation is written in terms of the growth rates of money, the desired ratio of money to income, and income, it becomes

(2) $\dot{M} = \dot{k} + \dot{Y}$,

where the dots over variables indicate their growth rates. If the growth rate of k, firms' and households' desired ratio of money to income, is independent of changes in the growth rate of the money supply, then changes in the growth of the money supply must be matched one-for-one by changes in the growth of nominal income. In other words, holding $\dot{k}$ constant, a 1 percentage point increase in money growth is associated with a 1 percentage point increase in nominal income growth.

This proposition is a *long-run* proposition. Suppose, for example, that the growth rate of the money supply has been 10 percent per year for a long time and the growth rate of k is 4 percent. Then, from equation (2), the growth rate of nominal income is 6 percent. If the growth rate of the money supply increases from 10 to 15 percent, the growth rate of nominal income will not increase from 6 percent to 11 percent immediately. It will be some time before the increase in spending occurs and the economy completely adjusts to the changed circumstances. The speed with which firms and households increase their spending after an increase in the money supply is affected by other things in the economy.[7] Eventually the economy will adjust, but as the data we present below indicate, the adjustment period may exceed one year.

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[5]Actually, a lot of evidence is consistent with it as well. A good summary is provided by Laidler (1977).

[6]This difference between the quantities of money demanded and supplied is contingent on a simple specification of equation 1. In a fully-specified model of the demand for money with all adjustment costs and state variables included, the quantity of money demanded always equals the quantity of money supplied.

[7]Interest rates and expectations about future inflation are two such factors. Gavin and Dewald (1987, pp. 22-24) present some interesting evidence for 39 countries consistent with the importance of changes in expected inflation.

While nominal income growth clearly is of some interest, the breakdown of nominal income growth into real growth and inflation is perhaps even more informative about the state of the economy. By definition, nominal income is the price level times real income. In terms of growth rates, the growth rate of nominal income equals the rate of increase of prices plus the growth rate of real income, or

$$(3) \quad \dot{Y} = \dot{P} + \dot{y},$$

where $\dot{P}$ is the rate of increase of the price level (the inflation rate), and $\dot{y}$ is the growth rate of real income. As equation 3 indicates, nominal income growth of 5 percent per year could occur with no inflation and real income growing at 5 percent per year. On the other hand, inflation could be 25 percent per year with real income falling 20 percent per year. Clearly, any given growth rate of nominal income can be associated with quite different inflation rates and real income growth rates.

Money and Real Income

A second proposition, pointed out forcefully by David Hume (1752), is:

> ***Proposition II:*** *Changes in the money supply are* not *associated with permanent changes in real income.*

With respect to real income growth, changes in the growth of money will have no effect. The basis for this proposition is quite simple. Real income and output, the quantity of goods and services produced, are the same thing. Over long periods of time, the quantity of goods and services produced in an economy is determined by the quantity of resources applied to producing goods and services, including land, labor and capital, as well as technology, workers' skills and knowledge. Under most circumstances, money plays a very minor role in the long run. Large changes in the growth of the money supply, for example a change from 0 to 1,000 percent per year, can sufficiently disrupt an economy that real income falls. Small changes, however, are unlikely to have such an effect.[8]

Money and Inflation

The third proposition is about inflation:

> ***Proposition III:*** *An increase in the growth rate of money, other things the same, will be matched by an equal increase in the rate of inflation.*

This proposition is derived from the two earlier ones. If changes in the growth rate of the money supply are associated one-for-one with changes in nominal income growth, then changes in the growth of the money supply must change real income growth or the inflation rate. The combination of the two propositions above implies that, in the long run, only the inflation rate is affected. Consequently, if the growth rate of money increases by 1 percentage point per year, then the inflation rate eventually must increase 1 percentage point per year as well.

This one-for-one relationship between the growth of the money supply and the inflation rate is the result of a relationship between money and spending which takes time to be played out, combined with the lack of a long-run relationship between money and real income. It would be surprising if this third proposition held each month, quarter or year. The length of the period over which it does apply is examined below.

THE DATA

These propositions can be examined in a variety of ways. One approach is to look at data for a specific country over a long time span, say, 100 years. Another approach, the one adopted here, is to use data across a large number of countries for a shorter time period. Because the propositions are, as Robert Lucas has noted, "characteristics of steady states [that is, long-run equilibria], . . . the ideal experiment for testing them would be a comparison of long-term average behavior across economies with different monetary policies but similar in other respects."[9]

The specific data set that we use includes data on nominal income, real income, the price level and the money stock for 62 countries. Income and the associated price indexes are calculated using

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[8]Changes in the money supply can be related to changes in real income. Indeed, many economists argue that, in one way or another, changes in the money supply are positively related to short-run changes in real income. This relationship is used to explain the changes in real income associated with business fluctuations.

[9]Lucas (1980), p. 1006. This approach has been used by, among others, Schwartz (1973), Lothian (1985) and Lucas (1986).

either Gross National Product (GNP) or Gross Domestic Product (GDP).[10] Nominal and real GNP are used if they are available and the price level is measured by the GNP deflator; otherwise, nominal and real GDP are used and the price level is measured by the GDP deflator.[11] The countries and the data are presented in the appendix.

The "long-term" growth rates for the economic variables used are averages of annual growth rates for five years, 1979 to 1984.[12] The "short-term" growth rates are annual growth rates for individual years. The focus on the recent period is deliberate: the relevance of money in recent years has been challenged. Therefore, a key issue is whether the propositions discussed above are supported by the data from the past few years.

MONEY, INCOME AND INFLATION

The Long-Run Evidence

The first proposition states that there is a one-to-one relationship between money growth and the growth of nominal income. To see if this is true, the long-run growth rates of money and income for the countries in our sample are shown in figure 1.[13] The scatter of points indicates that the data are consistent with this proposition. As the figure shows, there is a wide diversity in experience across countries. For 1979 to 1984, average money growth rates range from about 2 percent per year for Switzerland to 220 percent per year for Bolivia. The growth rate of nominal income also varies substantially, from about 5 percent per year for the United Arab Emirates to about 200 percent per year for Bolivia. More important, the points tend to lie on the reference line in the figure, which has a slope of one. This clustering of income and money growth rates along the line indicates a one-for-one correspondence between the two, consistent with proposition I.

Table 1

Income and Inflation Regressions: 1979 to 1984

Dependent variable	Coefficient estimates: Constant	Coefficient estimates: Growth rate of money	R^2
Growth rate of nominal income	1.592	1.007	0.96
	(1.128)	(0.027)	
Growth rate of real income	2.613	−0.018	0.07
	(0.366)	(0.009)	
Inflation rate	−1.354	1.031	0.96
	(1.055)	(0.025)	

NOTE: The symbol R^2 is the fraction of variation explained. Standard errors of the estimated coefficients are reported in parentheses.

To examine this proposition another way, we present a simple regression using the data in figure 1 in the first line of table 1. This regression is the estimated straight line which best fits the data for nominal income growth and money growth.[14] The regression is consistent with our observations about the graph. The estimated coefficient for money growth is 1.007, which indicates that an increase in money growth of 1 percentage point per year is associated with an increase in nominal income growth of almost exactly 1 percentage point per year. In addition, the statistic measuring the fraction of variation explained, the R^2, shows that 96 percent of the variation in the nominal income growth rates is explained by money growth. This corroborates the graphic evidence that money and nominal income growth are closely linked.

[10]GNP is defined as the current market value of all final goods and services produced by labor and property supplied by residents of the country. GDP is the current market value of all final goods and services produced by labor and property located in the country.

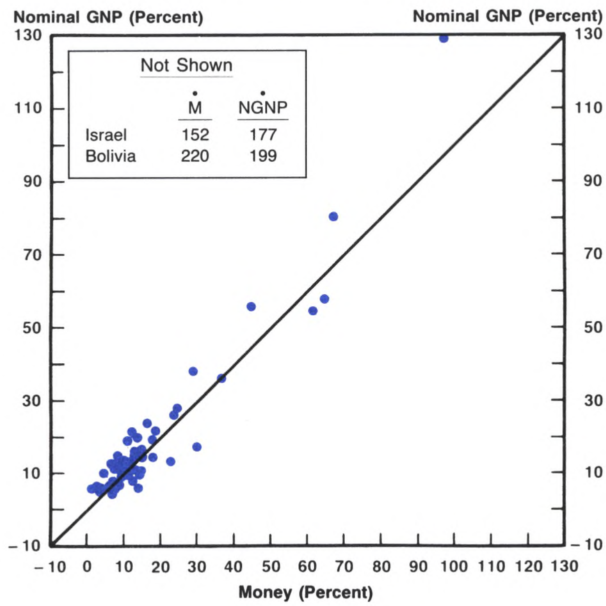
[11]The deflator simply is calculated as the ratio of nominal income to real income; for example, the GNP deflator is nominal GNP divided by real GNP.

[12]Although one may quibble whether five years is long enough to be long run, it seems to be long enough for transitory disturbances to average out.

[13]The propositions imply that the slope of the reference line should be one for nominal income growth and inflation. They do not imply that the lines pass through the origin, but they are drawn through the origin for convenience.

[14]The estimation technique used is ordinary least squares, which defines the "best" straight line as the one which minimizes the total sum of squared deviations of the dependent variable from the estimated line. The numbers in parentheses in the table are the standard errors of the estimated coefficients. These statistics are useful for testing hypotheses about the estimated coefficients. For example, suppose one wishes to determine whether the estimated coefficient is statistically different from zero. One need only divide the estimated coefficient by its standard error. If the resulting value — known as a t-statistic — exceeds some predetermined value, say 2, then the coefficient is said to be significantly different from zero. Another way of evaluating these regression results is to test whether the coefficient equals one. To test the hypothesis that an estimated coefficient is equal to one, the estimated coefficient minus one is divided by the reported standard error. A t-statistic less than 2 means that the hypothesis that the estimate equals one cannot be rejected.

Chart 1
Growth in Nominal GNP and Growth in Money: 1979 to 1984



The second proposition concerns the independence of money and real income growth in the long run. Figure 2 shows the countries' average money growth and real income growth rates for 1979 to 1984. In this figure, the reference line is drawn at the average real income growth rate across the countries. This line has a slope of zero, as implied by the second proposition. The data plotted in this graph suggest little relationship between the two. Some countries with extremely high money growth rates have low or even negative growth rates of real income. Bolivia, for example, has a 220 percent average annual growth rate of money even though real income over the period *declines* at an average annual rate of about 2 percent. Also, Israel's money growth is about 152 percent, but real income growth is only 2 percent per year.

In contrast, other countries have relatively low money growth and fast real income growth. Singapore, for instance, has an average real income growth of 8.6 percent over the five years and a 9 percent average money growth rate. This is below the average money growth of 23 percent for all the countries, but well above the average real growth of 2.2 percent per year.

This second proposition also can be examined by regressing real income growth on money growth; the result is presented in the middle row of table 1. The estimated coefficient on money growth is negative, suggesting that a faster expansion in the money supply lowers real income growth in the long run. Although an increase in money growth is associated with an *increase* in *nominal* income growth, the evidence suggests an increase in money growth is associated with a *decrease* in *real* income growth.[15]

The final proposition concerns the relationship between money growth and inflation. Is a 1 percentage-point increase in the growth rate of money reflected in a 1 percentage-point increase in the rate of inflation? Figure 3 shows money growth and inflation rates across the countries. The visual evidence supports a one-for-one corre-

[15]In a regression without Bolivia, the estimated coefficient of money growth is still negative, −0.014, but is no longer statistically different from zero.

Chart 2
Growth in Real GNP and Growth in Money: 1979 to 1984

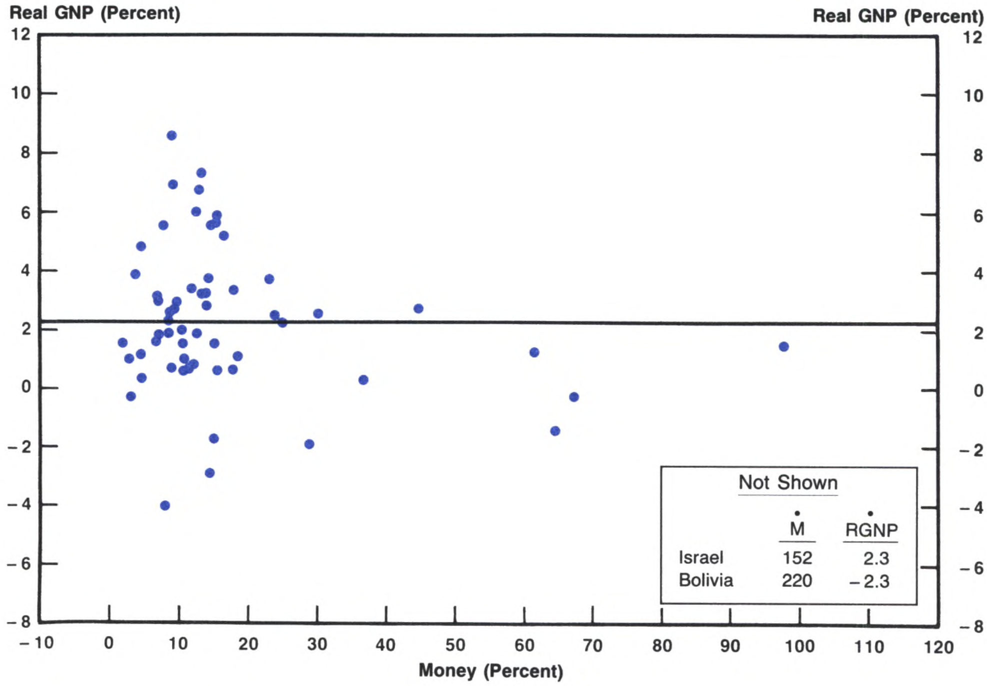
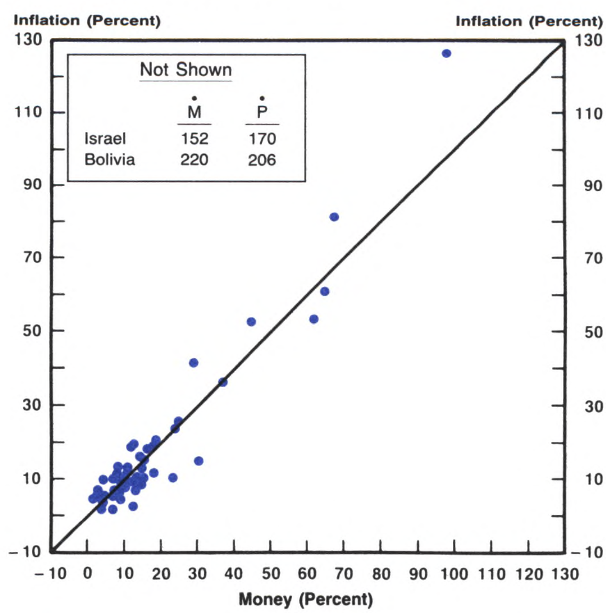


Chart 3
Inflation Rate and Growth in Money: 1979 to 1984



spondence: the points clearly are clustered around the reference line, indicating that countries with higher money growth on average similarly have higher rates of inflation.

The data shown in figure 3 also support this proposition when used in a regression of inflation on money growth. Reported in the last line in table 1, the regression results are consistent with a one-for-one link between money growth rates and inflation. The estimated coefficient of 1.031 indicates that an increase in the growth rate of money by 1 percentage point is associated with a similar increase in the inflation rate.

To recap the evidence, the data are generally consistent with the propositions set forth above. The data from 62 countries for 1979 to 1984 show that, holding other things constant: (1) there is a one-for-one connection between money growth and nominal income growth; (2) there is little systematic relationship between money growth and real income growth; and (3) there is a one-for-one connection between money growth and inflation. These results are not specific to this particular sample of countries or time period: evidence based on a smaller set of countries (40) for the period 1981-86 supports these same conclusions.[16]

The Short-Term Evidence

Given the evidence above, why then has the relevance of money come under such strong criticism in recent years? Perhaps one reason is that attempts to apply these long-run propositions to shorter time spans have led to disappointing results and erroneous rejection of the propositions. As Milton Friedman (1986) recently reiterated, the "time delay between changes in the quantity of money and in other magnitudes are 'long and variable' and depend a great deal on surrounding circumstances."

Two single years from the period suffice to illustrate the errors in attempting to use longer-run relationships to explain shorter-run outcomes. One year chosen is 1984, the most recent year for which data for all 62 countries are available. The other is 1979, the beginning of the period. How well do these long-run propositions fare in each year?

Figure 4 shows the data for nominal income and money growth for 1984; the association here appears somewhat looser than shown in figure 1. For instance, in 1984, Peru's money growth rate of 116 percent is associated with 128 percent growth in nominal income, while Iceland's money growth rate of 107 percent is associated with only a 33 percent rate of increase in nominal income. While these two countries offer convenient examples, the variety of income growth rates associated with a given money growth rate is sufficiently large to make the point. For example, 35 percent money growth is associated with nominal income growth rates ranging from 5 percent to 70 percent.[17]

The perception that the link between money and income is looser in 1984 than for the five-year period running from 1979 to 1984 is corroborated by a simple regression. The first row of table 2 presents regression results using data for 1984. The regression of income growth on money growth, unlike its companion equation in table 1, indicates that a 1 percentage-point increase in money growth is not associated with a like increase in income growth. Rather, nominal income growth increases by about three-fourths of a percentage point. This illustrates the point that the one-for-one proposition concerning income and money growth does not necessarily hold over shorter periods.[18]

Figure 5 shows the relationship between nominal income and money growth rates for 1979. The looseness of the shorter-run association between growth rates of money and nominal income again is evident. On the one hand, Israel and Zaire have nominal income growth rates of 92 percent and 103 percent and money growth rates of 0 and minus 2 percent, respectively. On the other hand, Haiti and Tanzania both have nominal income growth of about 11 percent and money growth

[16]The evidence based on the 40 countries with five-year average data through 1986 is similar. A regression of nominal GNP growth on money growth has a coefficient of 0.970 with a standard error of 0.020; a regression of real GNP growth on money growth has a coefficient of −0.012 with a standard error of .015; and a regression of the inflation rate on money growth has a coefficient of 0.965 with a standard error of 0.025.

[17]For example, Denmark has 35 percent money growth and 9 percent nominal income growth; Ecuador, 36 percent money growth and a 45 percent income growth rate; Bangladesh, 34 percent and 21 percent; Zaire, 38 percent and 68 percent; and Tanzania, 35 percent and 15 percent.

[18]The large outliers in figure 4 are Bolivia, Brazil and Israel. Are these countries responsible for the regression result in table 2? Deleting them and re-estimating the income-money equation produces an estimated coefficient of money growth of 0.689, again different from unity.

Chart 4
Growth in Nominal GNP and Growth in Money: 1984

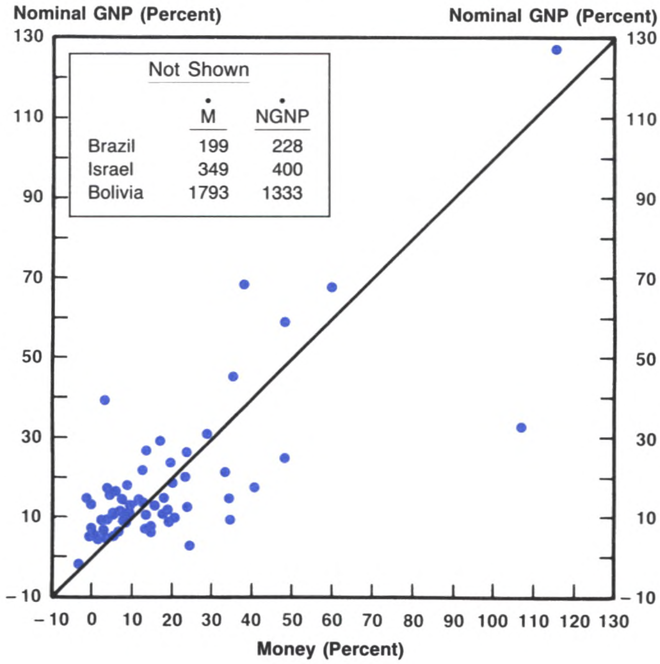


Table 2
Income and Inflation Regressions: 1979 and 1984

Dependent variable	Constant (Coefficient estimates)	Growth rate of money (Coefficient estimates)	R^2
	1984		
Growth rate of nominal income	7.191	0.756	0.98
	(3.093)	(0.013)	
Growth rate of real income	3.198	−0.002	0.03
	(0.407)	(0.002)	
Inflation rate	3.277	0.764	0.98
	(1.06)	(0.013)	
	1979		
Growth rate of nominal income	13.181	0.532	0.21
	(3.542)	(0.134)	
Growth rate of real income	3.889	0.037	0.03
	(0.726)	(0.027)	
Inflation rate	9.256	0.457	0.17
	(3.483)	(0.131)	

NOTE: The symbol R^2 is the fraction of variation explained. Standard errors of the estimated coefficients are reported in parentheses.

rates near 54 percent. Clearly, the link between money and income growth rates is much more variable on a one-year basis than over a span of five years.

The regression in table 2 for 1979 confirms that the short-run relationship between money and income is less reliable than the long-run relationship. The coefficient on money growth is only 0.53, far below unity. Moreover, the R^2 which is 98 percent in 1984, is only 21 percent for 1979. This dramatic switch in results indicates that using money growth to predict nominal income for a period as brief as one year is likely to be associated with large errors. Such short-term inaccuracy, however, does not obviate the underlying, long-run proposition supported by the evidence presented earlier.

Real income and money growth for 1984 are presented in figure 6. The figure suggests no discernable pattern. This is consistent with the proposition that real income growth is independent of money growth, even over a period as brief as a year. The associated regression in table 2 corroborates this: the estimated coefficient of money growth is not different from zero. Moreover,

Chart 5
Growth in Nominal GNP and Growth in Money: 1979

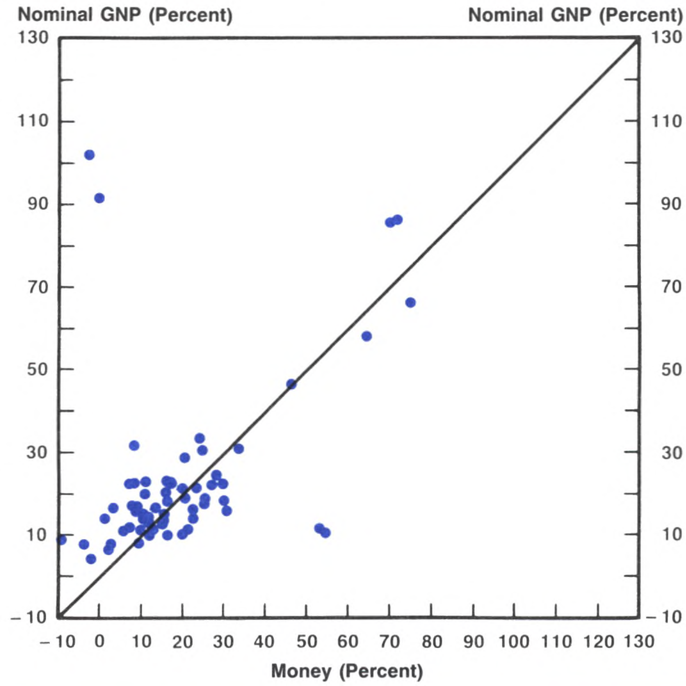


Chart 6
Growth in Real GNP and Growth in Money: 1984

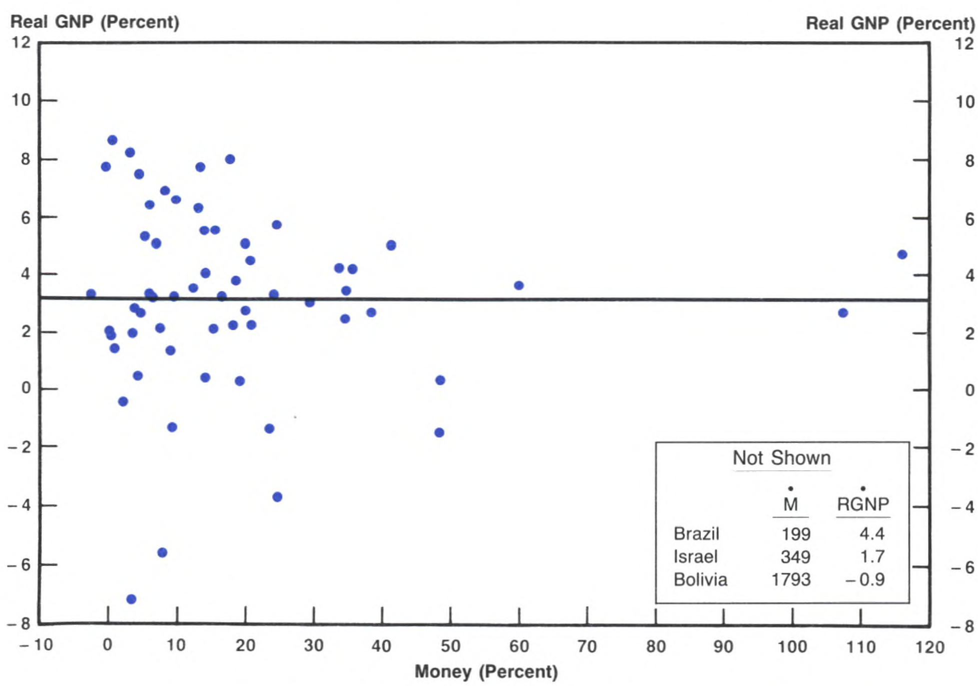
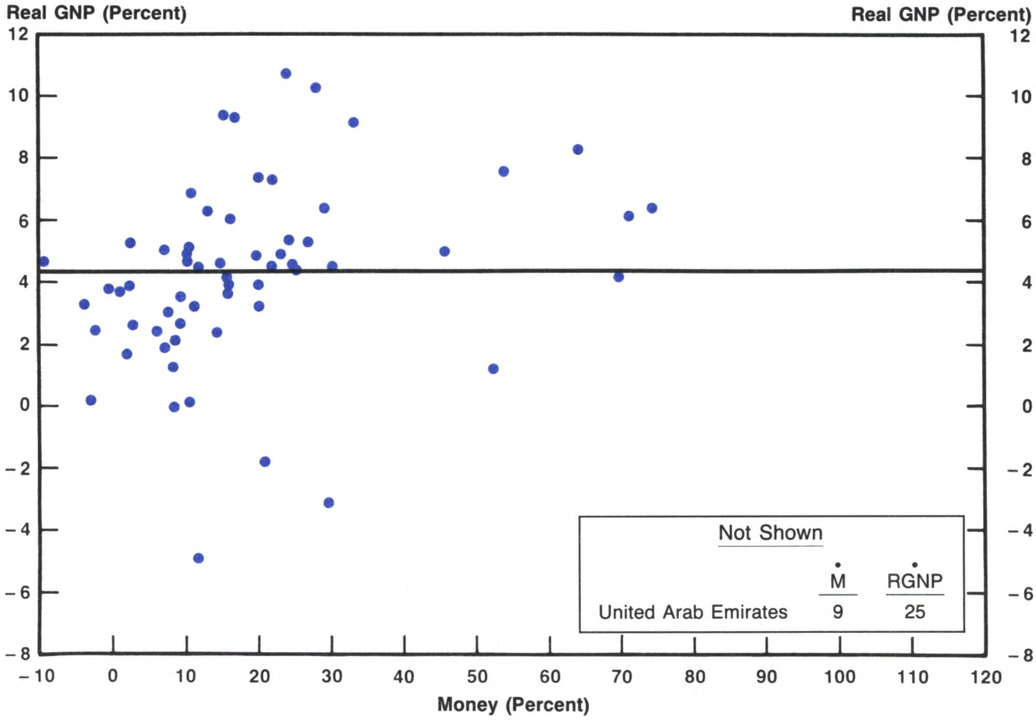


Chart 7
Growth in Real GNP and Growth in Money: 1979



money growth explains a mere 3 percent of the total variation in real income growth.[19]

A similar story unfolds using the data from 1979, which are plotted in figure 7. Austria and Peru provide a taste of this diversity. Austria has real income growth of 5 percent with a money growth rate of minus 9 percent. In stark contrast, Peru has real income growth of about 4 percent with a money growth rate of 70 percent. The regression in table 2 again points to no reliable relationship between money growth and real income growth: the estimated coefficient is roughly zero. The data for 1979, like the data for 1984, are consistent with the proposition that the variation of real income growth is largely independent of money growth.

As would be expected based on the results for nominal and real income for these two years, the relationship between money growth and inflation is quite loose in any single year. Figure 8 shows inflation and money growth for 1984. The graph does not suggest the one-for-one relationship found with the data for the five-year period. The relevant regression in table 2 is consistent with this observation. The regression reveals that, in 1984, a 1 percentage-point increase in the growth rate of money is associated with about a three-quarters of a percentage-point increase in inflation. Although significant and positive, the association obviously is not one-for-one.

The money growth and inflation data for 1979, presented in figure 9, show that 1984 is not abnormal. If anything, figure 9 reveals even greater variety in the combinations of inflation and money growth than the data for 1984 reveal. This observation is corroborated by the results of the regression in table 2. In contrast to 1984, the data for 1979 show a weak link between money growth and inflation. Not only is the R^2 of the equation low — only 17 percent of the variation in inflation is explained by money growth — but the estimated coefficient on money growth again is well below unity.

[19]With Bolivia, Brazil and Israel deleted, the estimated coefficient of money growth is −0.004, which does not alter our conclusion.

Chart 8
Inflation Rate and Growth in Money: 1984

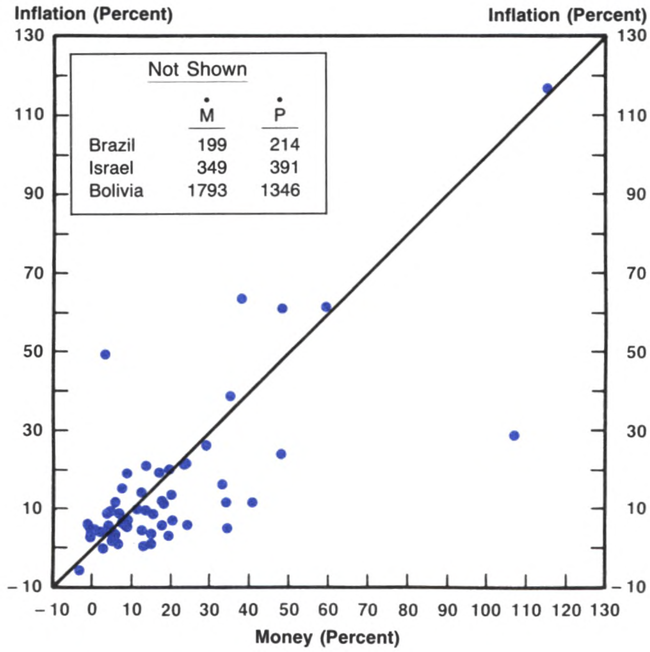
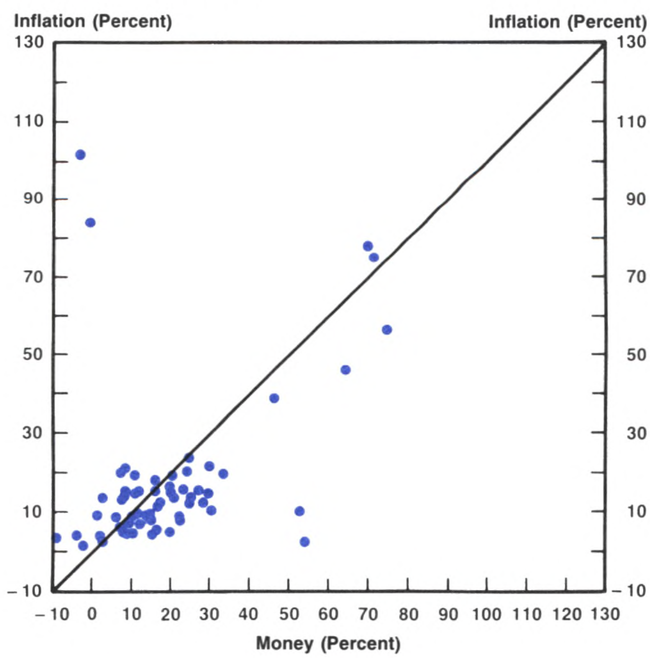


Chart 9
Inflation Rate and Growth in Money: 1979



The evidence in this section indicates that money's relevance cannot be judged accurately over shorter-run periods of one month, one quarter or even one year. Over such short-run periods, an increase in money growth may result in a substantial rise in the growth of nominal income — the evidence from 1984 — or show little effect on nominal income — the 1979 result. Similar results hold when assessing the short-run association between money growth and inflation.

CONCLUSION

Is money irrelevant? The short-run linkages between the growth rates of money, income (both nominal and real) and prices are, as we have shown, quite loose. In any particular year, higher money growth is not associated with an equal increase in nominal income or inflation. Even so, propositions about the importance of money in determining inflation in the longer run have not faded. Viewed in the proper time perspective, a higher growth rate of the money supply is associated with a higher inflation rate. Attempts to use the longer-run relationships between money growth and either nominal income growth or inflation for explaining short-run outcomes are likely to prove disappointing. Money's relevance will be substantially misjudged if attention is focused on the short run.

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Data Appendix

Data for 1979–84

Country	Money Growth	Inflation	Real Income Growth	Nominal Income Growth
United States	7.5%	6.5%	1.8%	8.5%
United Kingdom	11.8	9.5	0.7	10.2
Austria	7.1	5.3	1.6	6.9
Belgium	3.0	5.5	1.0	6.6
Denmark	15.4	8.4	1.5	10.1
France	10.9	10.3	1.5	12.0
Germany	4.7	3.7	1.1	4.9
Italy	13.0	19.5	1.8	21.7
Norway	13.6	10.2	3.2	13.6
Switzerland	2.1	4.6	1.5	6.2
Canada	10.7	7.7	1.9	9.8
Japan	4.0	2.2	3.9	6.1
Finland	12.1	9.5	3.4	13.1
Greece	18.9	20.4	1.1	21.6
Iceland	64.9	60.4	−1.4	58.1
Ireland	8.7	13.0	2.3	15.6
Australia	8.9	9.6	2.5	12.4
New Zealand	8.9	11.8	2.4	14.4
South Africa	30.5	14.9	2.5	17.8
Bolivia	220.3	205.9	−2.3	198.9
Brazil	98.0	126.5	1.5	129.9
Chile	18.2	18.9	0.6	19.6
Colombia	24.3	23.5	2.4	26.5
Costa Rica	37.1	36.0	0.3	36.4
Dominican Republic	14.1	10.7	3.2	14.3
Ecuador	25.2	25.5	2.2	28.3
El Salvador	8.2	10.7	−4.0	6.3
Guatemala	3.4	6.8	−0.3	6.5
Haiti	4.8	9.8	0.4	10.2
Honduras	9.2	7.1	0.7	7.9
Mexico	45.0	52.3	2.7	56.4
Panama	4.8	5.2	4.8	10.3
Paraguay	14.6	15.7	3.7	20.0
Peru	67.6	81.1	−0.3	80.6
Uruguay	29.2	41.3	−1.9	38.6
Venezuela	15.3	12.9	−1.7	10.9
Cyprus	14.9	10.0	5.5	16.1
Israel	152.0	170.3	2.3	176.6
Jordan	13.5	7.0	7.3	14.8
Syrian Arab Republic	23.4	10.0	3.7	14.1
United Arab Emirates	7.2	1.6	3.1	4.7
Bangladesh	18.2	11.4	3.3	15.2
Burma	12.8	2.6	6.0	8.7
Sri Lanka	16.8	18.0	5.1	24.0
India	15.6	8.8	5.5	14.8
Korea	15.8	10.7	5.8	17.1
Malaysia	9.5	4.2	6.9	11.4
Nepal	14.3	8.4	2.8	11.4
Pakistan	13.2	9.1	6.7	16.5
Philippines	12.3	18.4	0.8	19.3
Singapore	9.2	5.3	8.6	14.3
Thailand	8.0	6.3	5.5	12.2
Burundi	9.9	8.8	2.9	12.0
Zaire	61.8	53.2	1.2	55.1
Kenya	7.4	10.0	2.9	13.2
Malawi	11.2	13.5	1.0	14.6
Morocco	9.5	8.3	2.7	11.2
Nigeria	14.7	9.8	−2.9	6.6
Tanzania	15.9	15.0	0.6	15.7
Zambia	11.0	12.5	0.6	13.1
Papua New Guinea	5.0	5.6	0.3	5.9
Hungary	8.7	5.5	1.9	7.5

Data for 1979

Country	Money Growth	Inflation	Real Income Growth	Nominal Income Growth
United States	6.7%	8.8%	2.5%	11.5%
United Kingdom	9.1	14.5	2.2	17.1
Austria	−9.0	4.1	4.7	9.0
Belgium	2.5	4.6	1.7	6.3
Denmark	9.9	7.6	3.5	11.4
France	11.8	10.1	3.2	13.7
Germany	2.9	4.0	3.9	8.1
Italy	23.7	15.9	4.9	21.6
Norway	7.6	6.6	5.1	12.0
Switzerland	−1.9	2.0	2.5	4.5
Canada	1.4	10.0	3.7	14.1
Japan	3.0	3.0	5.3	8.5
Finland	22.5	8.3	7.3	16.3
Greece	16.3	18.6	3.7	23.0
Iceland	46.3	39.3	5.0	46.3
Ireland	8.1	13.7	3.1	17.2
Australia	15.4	8.2	4.7	13.2
New Zealand	3.4	13.8	2.7	16.8
South Africa	20.7	15.1	3.2	18.8
Bolivia	11.1	19.7	0.2	19.9
Brazil	74.9	56.8	6.4	66.8
Chile	64.5	46.3	8.3	58.4
Colombia	24.8	24.0	5.4	30.7
Costa Rica	10.7	9.1	4.9	14.5
Dominican Republic	30.7	11.1	4.5	16.1
Ecuador	27.4	16.1	5.3	22.3
El Salvador	21.5	13.9	−1.7	11.9
Guatemala	10.7	8.6	4.7	13.7
Haiti	54.3	2.9	7.6	10.7
Honduras	13.6	9.6	6.3	16.5
Mexico	33.7	20.2	9.2	31.2
Panama	22.5	9.2	4.5	14.2
Paraguay	24.4	20.6	10.7	33.5
Peru	70.3	78.3	4.3	85.9
Uruguay	71.6	75.5	6.2	86.3
Venezuela	8.9	21.3	1.3	22.9
Cyprus	28.5	13.0	10.3	24.6
Israel	0.0	84.6	3.8	91.7
Jordan	25.7	14.1	4.4	19.1
Syrian Arab Republic	16.2	15.5	4.2	20.3
United Arab Emirates	8.5	5.4	25.0	31.8
Bangladesh	25.4	12.9	4.6	18.1
Burma	11.1	5.6	5.2	11.1
Sri Lanka	29.7	15.4	6.4	22.8
India	12.2	15.6	−4.8	10.0
Korea	20.7	19.9	7.4	28.8
Malaysia	17.2	12.1	9.3	22.5
Nepal	15.2	10.0	2.4	12.6
Pakistan	20.4	5.5	4.9	10.6
Philippines	11.2	15.2	6.9	23.2
Singapore	15.8	5.2	9.4	15.1
Thailand	16.6	11.6	6.1	18.4
Burundi	7.8	20.3	2.0	22.7
Zaire	−2.4	102.1	0.3	102.6
Kenya	16.5	6.2	3.9	10.4
Malawi	−3.4	4.5	3.3	8.0
Morocco	12.4	7.6	4.5	12.5
Nigeria	20.5	16.8	3.9	21.4
Tanzania	52.9	10.6	1.2	12.0
Zambia	30.2	21.9	−3.1	18.2
Papua New Guinea	9.2	15.5	0.0	15.5
Hungary	10.0	5.5	2.7	8.4

Data for 1984

Country	Money Growth	Inflation	Real Income Growth	Nominal Income Growth
United States	5.9%	3.9%	6.4%	10.5%
United Kingdom	15.4	4.1	2.2	6.4
Austria	3.5	4.8	2.0	6.9
Belgium	0.3	5.5	1.9	7.4
Denmark	34.7	5.7	3.5	9.3
France	8.9	7.5	1.4	8.9
Germany	5.9	2.0	3.3	5.3
Italy	12.4	10.2	3.5	14.1
Norway	24.4	6.4	5.7	12.5
Switzerland	0.1	2.9	2.0	5.0
Canada	19.9	3.8	5.1	9.1
Japan	6.9	1.2	5.1	6.4
Finland	16.4	9.2	3.3	12.8
Greece	20.2	20.3	2.7	23.6
Iceland	107.4	29.0	2.7	32.6
Ireland	9.6	7.7	3.2	11.1
Australia	8.2	7.0	6.9	14.4
New Zealand	9.8	5.6	6.6	12.6
South Africa	41.2	12.0	5.1	17.7
Bolivia	1793.3	1345.7	−0.9	1332.5
Brazil	198.5	214.3	4.4	228.2
Chile	13.1	14.3	6.3	21.5
Colombia	24.1	22.2	3.4	26.3
Costa Rica	17.6	19.4	8.0	29.0
Dominican Republic	48.4	24.5	0.4	25.0
Ecuador	35.6	39.2	4.2	45.0
El Salvador	18.3	12.3	2.3	14.8
Guatemala	4.3	4.2	0.5	4.6
Haiti	19.2	11.1	0.3	11.5
Honduras	3.8	4.2	2.8	7.1
Mexico	60.0	61.8	3.7	67.7
Panama	2.3	4.8	−0.4	4.4
Paraguay	29.4	26.9	3.1	30.8
Peru	116.0	117.2	4.8	127.5
Uruguay	48.4	61.5	−1.5	59.1
Venezuela	23.8	21.6	−1.4	20.0
Cyprus	4.4	8.9	7.5	17.0
Israel	348.5	391.3	1.7	399.5
Jordan	1.0	3.9	1.5	5.4
Syrian Arab Republic	25.0	6.7	−3.6	2.8
United Arab Emirates	−2.6	−5.0	3.3	−1.9
Bangladesh	33.6	16.4	4.2	21.3
Burma	15.5	1.9	5.6	7.6
Sri Lanka	14.1	21.5	4.1	26.4
India	18.5	6.4	3.8	10.5
Korea	0.5	3.9	8.6	12.9
Malaysia	−0.6	6.1	7.8	14.4
Nepal	13.2	5.0	7.8	13.1
Pakistan	5.2	9.6	5.3	15.5
Philippines	3.5	49.8	−7.1	39.2
Singapore	3.0	0.7	8.2	9.0
Thailand	14.1	1.3	5.5	6.9
Burundi	6.4	12.4	3.2	16.0
Zaire	38.3	64.0	2.7	68.4
Kenya	14.1	10.0	0.4	10.4
Malawi	20.7	13.7	4.5	18.8
Morocco	7.6	9.1	2.2	11.5
Nigeria	8.2	15.6	−5.5	9.2
Tanzania	34.6	11.9	2.5	14.7
Zambia	9.4	19.5	−1.3	17.9
Papua New Guinea	20.9	7.6	2.2	10.0
Hungary	4.8	6.3	2.7	9.2

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The October Crash: Some Evidence on the Cascade Theory

"It's the nearest thing to a meltdown that I ever want to see."
John J. Phelan, Jr., Chairman of the New York Stock Exchange

THE record one-day decline in stock prices on October 19, 1987, stripped roughly 22 percent from stock values. More disconcerting, however, were the speed of the adjustment, the tumultuous trading activity in financial markets and the uncertainty that prevailed during the week of October 19. These aspects of the crash bore a surprising resemblance to previous financial panics that many thought were historical artifacts outmoded by modern regulatory and surveillance systems as well as by advances in the financial sophistication of market participants. The crash shocked this complacency and reawakened considerable interest in financial panics and their causes.

As with its 1929 predecessor, the list of popular explanations for the panic of 1987 runs the gamut from the purely economic and financial to the frailties inherent in human nature (see opposite page). Recently, a number of more-or-less official investigating agencies have released reports about the October panic.[1] Generally speaking, these reports do not attempt to identify the reason for the decline in stock prices. Rather, they focus on the factors that characterized it as a panic: the *sharpness* of the decline on October 19 and the *tumultuous* trading activity that occurred on this day and during the following week.

Virtually all of the reports agree that the inability of the New York and other cash market exchanges to process the unprecedented volume of trades quickly contributed importantly to the market turmoil. They disagree widely, however, about the reasons for the sharpness of the decline.

The Brady Commission Report attributes the downward "cascade" in stock prices to programmed trading — more specifically, to the trading strategies known as index arbitrage and portfo-

[1]See, for example, the *Report of the Presidential Task Force on Market Mechanisms* (1988); U.S. General Accounting Office (1988); U.S. Commodity Futures Trading Commission (1988); and the report of Miller, Hawke, Malkiel and Scholes (1987).

Some Popular Notions Regarding the Crash of '87

"Wall Street has supplanted Las Vegas, Atlantic City, Monte Carlo and Disneyland as the place where dreams are made, where castles appear in the clouds. It was Pinocchio's Pleasure Island, where children (and the adults whose bodies they inhabited) could do and have whatever they wanted, whenever they wanted it.

But now it's morning and the binge seems to be over. Many have hangovers. Many have worse. The jackasses are clearly identifiable. And the rest of us, who pretended not to notice, are left with the job of cleaning up the mess."

Robert B. Reich, *New York Times* (October 22, 1987)

"People are beginning to see that the five-year bull market of the Eighties was a new Gatsby age, complete with the materialism and euphoric excesses of all speculative eras. Like the Jazz Age of F. Scott Fitzgerald's . . ., the years combined the romance of wealth and youth with the slightly sinister aura of secret understandings."

William Glaberson, *New York Times* (December 13, 1987)

"We've been through quite a few years in which we felt we had reached the millennium, which was high rewards and no risk. We are now understanding that that is not the case."

Peter G. Peterson, *New York Times* (December 13, 1987)

"Ultimately, we will view this period as one in which we made a very important mistake. What we did was divorce our financial system from reality."

Martin Lipton, *New York Times* (December 13, 1987)

"Investors knew that stocks were overpriced by any traditional valuation measure such as price/earnings ratios and price to book value. They also knew that the combination of program trading and portfolio insurance could send prices plummeting."

Anise C. Wallace, *New York Times* (November 3, 1987)

"On Monday, October 19, Wall Street's legendary herd instincts, now embedded in digital code and amplified by hundreds of computers, helped turn a sell-off into a panic."

David E. Sanger, *New York Times* (December 15, 1987)

"Futures and options are like barnacles on a ship. They take their life from the pricing of stocks and bonds. When the barnacles start steering the ship, you get into trouble, as we saw last week."

Marshall Front, *Christian Science Monitor* (October 30, 1987)

"One trader's gain is another's loss, and the costs of feeding computers and brokers are a social waste."

Louis Lowenstien, *New York Times* (May 11, 1988).

"We probably would have had only a 100- to 150-point drop if it hadn't been for computers."

Frederick Ruopp, *Christian Science Monitor* (October 30, 1987)

"This [restrictions on programmed trading] will make it a market where the individual investor can tread without fear of the computers."

Edward A. Greene, *New York Times* (November 3, 1987).

"In my mind, we should start by banning index option arbitrage and then proceed with other reforms which will restore public confidence in the financial markets. The public has every reason to believe that the present game is rigged. It is. Many would be better off in a casino since there people expect to lose but have a good meal and a good time while they're doing it."

Donald Regan, U.S. Senate Hearing, Committee on Banking, Housing and Urban Affairs (May 24, 1988, pp. 76–77).

The Trading Strategies

Portfolio insurance is an investment strategy that attempts to insure a return for large portfolios above some acceptable minimum. For example, if the acceptable minimum return is 8 percent and the portfolio is currently returning 13 percent, the portfolio's managers may want to decrease the share of the portfolio held in bonds and cash, which are safe but yield relatively low returns, and increase the share of the portfolio held in higher-yielding stock. This increases the expected return of the portfolio but exposes it to more risk. On the other hand, a stock price decline that reduced the return of the portfolio to, say, 10 percent puts the return close to the minimum. In this event, the managers may want to reduce the risk exposure of the portfolio. This can be accomplished by reducing the share of the portfolio held in stock and increasing the shares held in cash and bonds.[1]

This strategy results in stock purchases when stock prices rise significantly and stock sales when stock prices decline significantly.[2] Initially, these portfolio adjustments typically are made by trading in stock index futures, because the transaction cost for large baskets of stock are lower in futures than in the cash market.[3]

Index arbitrage is a trading strategy based on simultaneous trades of stock index futures and the corresponding basket of stocks in the cash market. This trading strategy attempts to profit from typically small and short-lived price discrepancies for the same group of stocks in the cash and futures markets.

Cash and futures prices for the same stock or group of stocks typically differ. The difference — called the basis — results from the "cost of carrying" stocks over the time interval spanned by the futures contract. These costs depend on the relevant interest rate and the dividends the stocks are expected to pay during the interval. On occasion, the observed basis may diverge from the cost of carry. If so, arbitrageurs can expect to profit *if simultaneous trades* can be placed in the two markets — purchasing the relatively low-priced instrument and selling the relatively high-priced instrument. These trades move the basis back to the cost of carry.

[1]See Miller, Hawke, Malkiel and Scholes (1987), p. 12.

[2]The purpose of this paper is not to evaluate the wisdom of these trading strategies. Rather, it is to evaluate the proposition that they contributed importantly to the panic.

[3]For example, the transaction costs of trading one futures contract based on the Standard and Poor's 500 are about $500 lower than trading the equivalent basket of stocks in the cash market. See Miller, Hawke, Malkiel and Scholes (1987), p. 11, and U.S. General Accounting Office (1988), p. 20.

lio insurance (see above for a discussion of these strategies).[2] This conclusion, however, is questioned seriously in reports filed by the Commodity Futures Trading Commission (CFTC) and Chicago Mercantile Exchange (CME).[3] These reports attribute the swift decline in stock prices to a massive revision in investors' perceptions of the fundamental determinants of stock prices.[4] Furthermore, since different rules govern trading in the cash and futures markets, a careful analysis of the effect of these different rules may better explain the evidence advanced by the Brady Commission in support of the cascade theory.[5]

This paper examines minute-by-minute price data gathered from the cash and futures market for stocks from October 15–23 to determine if the data are best explained by the cascade theory or the different trading rules in the two markets.

Resolving this issue is important because of the legislative and regulatory proposals spawned by the October panic. For example, the regulatory

[2]See the *Report of the Presidential Task Force on Market Mechanisms* (1988), pp. v, 15, 21, 29, 30 and 34–36.

[3]See U.S. Commodity Futures Trading Commission (1988), pp. iv, v, viii and 38–138 (especially p. 137); and Miller, Hawke, Malkiel and Scholes (1987), pp. 6, 8, 10–11, 41–43 and 55–56.

[4]See U.S. Commodity Futures Trading Commission (1988), p. ix; and Miller, Hawke, Malkiel and Scholes (1987), p. 6.

[5]See Miller, Hawke, Malkiel and Scholes (1987), pp. 21–23, 25, 37 and 49–50.

proposals advanced by the Brady Commission include:

(1) One agency to coordinate regulatory issues that have an impact across all financial markets;
(2) Unified clearing systems across related financial markets;
(3) Consistent margin requirements in the cash and futures markets;
(4) Circuit breaker mechanisms (such as price limits and coordinated trading halts); and
(5) Integrated information systems across related financial markets.[6]

Proposals 3 and 4 clearly reflect the Commission's belief that programmed trading contributed significantly to the panic. Furthermore, the action taken by the New York Stock Exchange (NYSE) to restrict use of its Designated Order Turnaround (DOT) system by program traders suggests that the officials of this exchange also subscribe to the Brady Commission's explanation.[7] This belief was reaffirmed more recently. Beginning February 4, 1988, the NYSE has denied use of the DOT system to program traders whenever the Dow Jones Industrial Average moves up or down by more than 50 points from its previous day's close.

THE CASCADE THEORY

The Brady Commission suggests that the stock market panic is best explained by the "cascade theory." This theory argues that "mechanical, price-insensitive selling" by institutions using portfolio insurance strategies contributed significantly to the break in stock prices.[8] In an effort to liquidate the equity exposure of their portfolios quickly, these institutions sold stock index futures contracts in the Chicago market. Such sales lowered the price of the futures contracts *relative* to the price of the equivalent basket of stocks in the New York cash market. The decline in the futures price relative to the cash price induced index arbitrageurs to purchase futures contracts in the Chicago market (which, in their view, were undervalued) and sell (short) the underlying stocks in the New York market (which, in their view, were overvalued relative to futures). Thus, index arbitrage transmitted the selling pressure from the Chicago futures market to the New York cash market causing cash prices in New York to decline.

The story does not end here. According to the theory, the decline in cash prices triggered a further selling wave in the Chicago market by portfolio insurers that index arbitrageurs, again, transmitted to the New York market. This process was repeated time after time causing a "downward cascade" in stock prices.[9]

The Brady Commission suggests that support for the cascade theory can be found by examining the behavior of the spread (the basis) between the price of stock index futures contracts and the cash prices of the shares underlying the contracts.[10] The basis is normally positive. Stock index futures prices generally exceed cash prices because the net costs of carrying stock forward (interest cost less expected dividends) are typically positive.[11] During the panic, however, the basis turned negative. The Commission suggests that this observation is consistent with the cascade theory.

Chart 1 plots both the price of the December Standard and Poor's 500 futures contract and the Standard and Poor's index of 500 common stocks. The latter represents the cash price of the stocks underlying the futures contract. The data cover half-hour intervals during October 15–23, 1987. Chart 2 plots the basis — the difference between the two prices shown in chart 1. As one can see, the basis fell below zero in the late afternoon of October 16 and, with a few exceptions, remained negative for the rest of the week. In the Brady Commission's view, this evidence provides important support for the cascade theory.

THERE IS LESS TO THE CASCADE THEORY THAN MEETS THE EYE

The Negative Basis

As mentioned, proponents of the cascade theory suggest that their theory is supported by the nega-

[6]*Report of the Presidential Task Force on Market Mechanisms* (1988), p. vii.

[7]The DOT System is a high-speed, order-routing system that program traders use to execute simultaneous trades in the cash and futures markets.

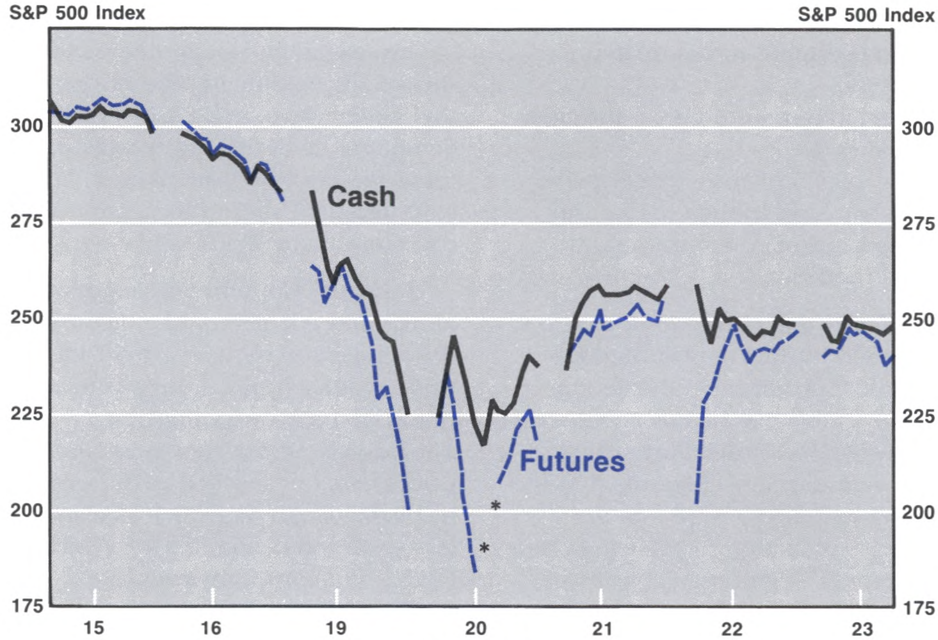
[8]*Report of the Presidential Task Force on Market Mechanisms* (1988), p. v.

[9]*Ibid.*, pp. 15, 17, 21, 30–36 and 69. It is apparent that our knowledge of stock market panics has advanced considerably in the 58 years since the 1929 crash. "Black Tuesday" was caused by a downward price "spiral." "Bloody Monday" was a "cascade."

[10]*Report of the Presidential Task Force on Market Mechanisms* (1988), pp. III.1–III.26, especially III.16–III.22.

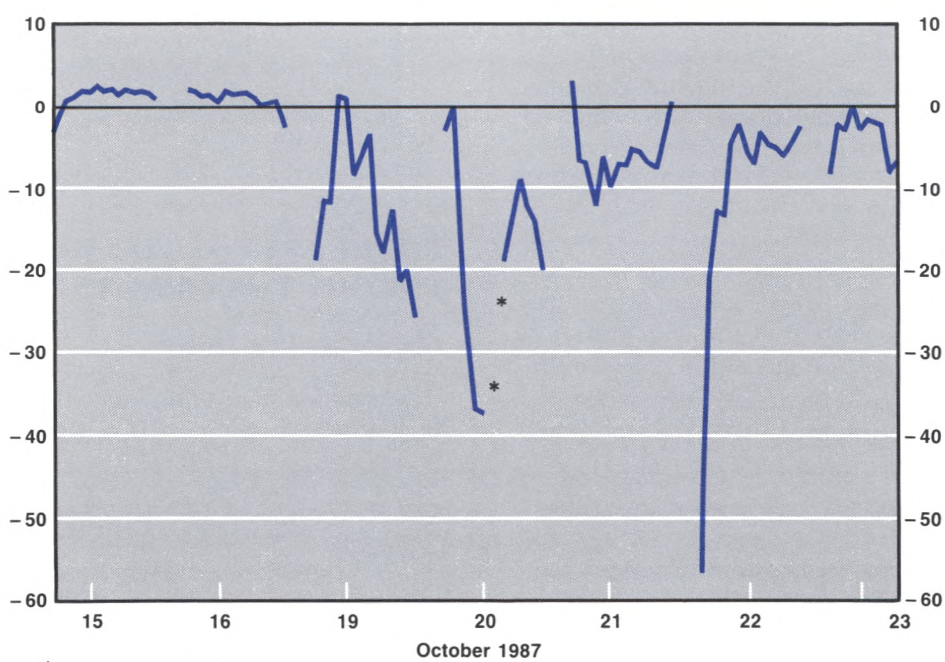
[11]See Figlewski (1984), pp. 658–60; Burns (1979), pp. 31–57; Cornell and French (1983), pp. 2–4; Modest and Sundaresan (1983), pp. 22–23; Santoni (1987), pp. 23–25; Schwarz, Hill and Schneeweis (1986), pp. 326–46; Working (1977); Kawaller, Koch and Koch (1987), p. 1311.

Chart 1
Cash and December Futures



*Futures market closed

Chart 2
Basis = December Futures – Cash



*Futures market closed

Table 1

Calculating the Basis

Panel A

Assumptions:

$D_t = \$1.00$

$g = 5.0\%$

$E_tD_{t+1} = D_t(1+g) = \$1.05$

$r = 11\%$

(1) $P_t = E_tD_{t+1}/(r-g) = \$1.05/.06 = \$17.50$

(2) $E_tP_{t+1} = P_t(1+r) - E_tD_{t+1} = \$17.50(1.11) - \$1.05 = \$18.38$

(3) $B = E_tP_{t+1} - P_t = \$18.38 - \$17.50 = \$\ .88$

Panel B

Assumptions: Same as A except $g' = 3.0\%$

(1) $P'_t = E_tD'_{t+1}/(r-g') = \$1.03/.08 = \$12.88$

(2) $E_tP'_{t+1} = P'_t(1+r) - E_tD'_{t+1} = \$12.88(1.11) - \$1.03 = \$13.27$

(3) $B' = E_tP'_{t+1} - P'_t = \$13.27 - \$12.88 = \$\ .39$

where:

D_t = the current dividend

E_tD_{t+1} = the expected dividend at year end

P_t = the current share price

g = the expected growth rate in dividends

r = the relevant long-term interest rate

tive basis observed on the afternoon of October 16 and on subsequent trading days during the week of October 19. However, a negative basis does not necessarily support the cascade theory.

Panel A of table 1 calculates the current price of a stock, P_t, assuming that the currently observed dividend, D_t, is \$1; the long-term interest rate, r, is 11 percent and the expected growth rate in dividends, g, is 5 percent.[12] Under these assumptions, the current price of the stock is \$17.50(= \$1.05/[.11 − .05]). In addition, panel A calculates the expected price of the stock one year from now, E_tP_{t+1}. This expected price is the amount to which P_t would grow if invested at r less the dividend expected at the end of the year, E_tD_{t+1}.[13] This amount is \$18.38(= \$17.50[1.11] − \$1.05). Assuming that arbitrageurs are rational and that transaction costs are very low, the basis between the price of a futures contract dated to mature in one year and the current cash price of the stock is the difference between the expected price of the stock one year from now and its current price, \$.88(= \$18.38 − \$17.50).

Panel B performs similar calculations assuming that the expected growth rate in dividends, g, falls from 5 percent to 3 percent, while everything else

[12]See Brealey (1983), pp. 67–72.

[13]The example assumes that the yield curve is flat.

remains constant. Notice that this results in a decline in the current price of the stock from $17.50 to $12.88, a reduction of about 30 percent. Furthermore, since the expected price of the stock one year from now falls to $13.27, the basis falls to $.39(= $13.27 − $12.88). Other things the same, a decline in the expected growth rate of dividends causes a decline in the current price, the futures price and the basis. For reasons discussed later, futures prices typically respond to new information more rapidly than indexes of cash market prices. This was particularly so during the crash. In terms of our example, if the futures price declines immediately to $13.27 but cash prices adjust less quickly, the *observed* basis may be negative during the adjustment period. In short, there is no need for a special theory, like the cascade theory, to explain the behavior of the basis during the week of October 19.[14]

Irrational Price-Insensitive Traders

Stock prices declined throughout the day of October 19, 1987. The decline was particularly sharp in the afternoon (see chart 1). At about 1:30 p.m. EST, the price of a December S&P 500 futures contract was about 15 points lower than the cash prices of the stocks underlying the contract (that is, the basis was −15 points, see chart 2). This means that liquidating the basket of stocks underlying the S&P 500 through futures market sales was about $7,500 more costly (before transaction costs) than liquidating the same basket in the cash market.[15] Yet, according to the cascade theory, portfolio insurers continued to liquidate in the futures market. In the words of the Brady Commission, this apparently anomalous behavior was the result of "mechanical price-insensitive selling." Put more bluntly, the theory attributes the observation to irrationality on the part of portfolio managers who, by most accounts — including those of the Brady Commission — are credited with being highly sophisticated financial experts.

The Missing Arbs

The cascade theory depends on index arbitrage activity to transmit selling pressure from the futures to the cash market. Yet, by all accounts, index arbitrage virtually ceased about 1:30 p.m. EST on October 19.[16] Cash market prices, however, fell sharply between 1:30 and the market's close. The S&P 500 index lost about 30 points during this time, while the Dow fell by more than 300 points. Furthermore, index arbitrage was severely restricted in subsequent trading days because the NYSE limited use of its DOT system by arbitrageurs. However, this did not prevent a further sharp decline in stock prices on October 26.

Foreign Markets and Previous Panics

The cascade theory fails to explain why stock market panics in foreign markets occurred at the same time as the U.S. panic. Programmed trading is virtually nonexistent in overseas markets. Yet these markets crashed as quickly and by as much as the U.S. market. Between October 16 and 23, for example, the U.K. stock market declined 22 percent, the German and Japanese markets fell 12 percent, the French market fell 10 percent and the U.S. market declined 13 percent. What's more, programmed trading dates back no further than 1982 when stock index futures contracts began trading. U.S. stock market panics have a much longer history. Since the cascade theory does not explain these other panics, there is some reason to be skeptical about its usefulness in explaining the latest U.S. panic.

AN ALTERNATIVE EXPLANATION: EFFICIENT MARKETS

A long-standing proposition in both economics and finance is that stock prices are formed in efficient markets.[17] This means that all of the relevant information currently known about interest rates, dividends and the future prospects for firms (the fundamentals) is contained in current stock prices. Stock prices change only when new information regarding the fundamentals is obtained by someone. New information, by definition, cannot be predicted ahead of its arrival; because the news is just as likely to be good as it is to be bad, jumps in stock prices cannot be predicted in advance.

If the efficient markets hypothesis is correct, past price changes contain no useful information

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[14]See, in addition, Malkiel (1988), pp. 5–6.

[15]The value of a S&P 500 futures contract is $500 times the level of the index. Consequently, if the cash market index is about 255 and the futures market index is about 240 as they were at 1:30 p.m. EST on October 19, the value of the basis: B = $500(240) − $500(255) = −$7,500.

[16]See the *Report of the Presidential Task Force on Market Mechanisms* (1988), pp. vi, 32 and 40; U.S. General Accounting Office (1988), pp. 43 and 45–46; U.S. Commodity Futures Trading Commission (1988), pp. vi and 46.

[17]See Brealey and Meyers (1984), pp. 266–81; Malkiel (1981), pp. 171–79; Brealey (1983), pp. 15–18; Leroy (1982) and Fama (1970).

about future price changes. With some added assumptions, this can be translated into a useful empirical proposition. If transaction costs are low, the expected return to holding stock is constant and the volatility of stock prices does not change during the time period examined, the efficient market hypothesis implies that observed *changes* in stock prices will be uncorrelated. The sequence of price changes are unrelated; they behave as random variables. This is sometimes called "weak form efficiency."

This implication contrasts sharply with a central implication of the cascade theory. The cascade theory suggests that price changes in both the cash and futures markets are positively correlated with their own past. This follows from the theory's circularity which attributes sharp price declines to immediately preceding sharp declines.

The behavior of U.S. stock prices generally conforms to the efficient markets hypothesis in the sense that past changes in stock prices contain no *useful* information about future changes.[18] However, when data on stock price indexes are observed at very high frequency (intra-day but not day-to-day), changes in the level of *cash* market indexes are correlated and appear to lag changes in futures prices.[19] This behavior appears to favor the cascade theory. When differences in the "market-making" techniques employed in the cash and futures markets are taken into account, however, intra-day data from both markets reject the cascade theory, while, on the whole, they are consistent with the efficient markets hypothesis.[20]

Market-Making in the Cash Market

Trading on the NYSE is conducted by members who trade within an auction framework at posts manned by specialists.[21] Specialists' activities are concentrated on a particular group of stocks that are traded at a particular post. One of the main functions of a specialist is to execute limit orders for other members of the Exchange. A limit order is an order to buy (sell) a specified number of shares of a given stock when and if the price of the stock falls (rises) to some specified level. The specialist maintains a book in which these orders are recorded and to which only he has access. The ability to place a limit order with a specialist frees the broker who places the order from having to wait at the post for a price movement that may never occur.

For example, suppose the information contained in the specialist's book for shares of XYZ corporation is summarized in figure 1.[22] The demand curve aggregates the purchase orders that have been placed with the specialist. These include bids of $9^7/_8$ for 400 shares, $9^3/_4$ for 300 shares, etc. The supply curve aggregates the specialist's sell orders of 100 shares at $10^1/_8$, 200 shares at $10^1/_4$, etc. Brokers, standing at the post, trade XYZ shares with each other and the specialist. At any time, a broker may request a quote from the specialist who, given the information in figure 1, would respond "$9^7/_8$ for 400, 100 at $10^1/_8$." This indicates that the specialist has buy orders for 400 shares at $9^7/_8$ and sell orders for 100 shares at $10^1/_8$. If the buy and sell orders of the other brokers at the post are in balance at the current price, trading in XYZ shares will occur within the price range of $9^7/_8$ bid and $10^1/_8$ ask.[23]

Suppose, however, that a broker has a market buy order for 300 shares that he is unable to cross with a broker with sell orders for 300 shares at the quoted spread (in this case, at an ask price of $10^1/_8$ or less). Since the specialist's quote indicates that he will sell 100 shares at $10^1/_8$, the broker will respond "Take it." The broker has purchased 100 shares from the specialist at $10^1/_8$. Since the broker must buy another 200 shares, he will ask for a further quote. If nothing further has occurred, the specialist will quote "$9^7/_8$ for 400, 200 at $10^1/_4$." The broker will respond "Take it." The broker has satisfied the market buy order for 300 shares of XYZ. He purchased 100 shares at $10^1/_8$ and 200 shares at $10^1/_4$. Of course, the broker could have acquired 300 shares immediately by offering to pay a price of $10^1/_4$ but the cost would have been greater. Instead, it pays the broker to try to "walk up" the supply curve by executing a number of trades rather than jumping directly to the price that will get him 300 shares in

[18]Malkiel (1981), Brealey (1983) and Fama (1970).

[19]See Perry (1985); Atchison, Butler and Simonds (1987) and Harris (1988).

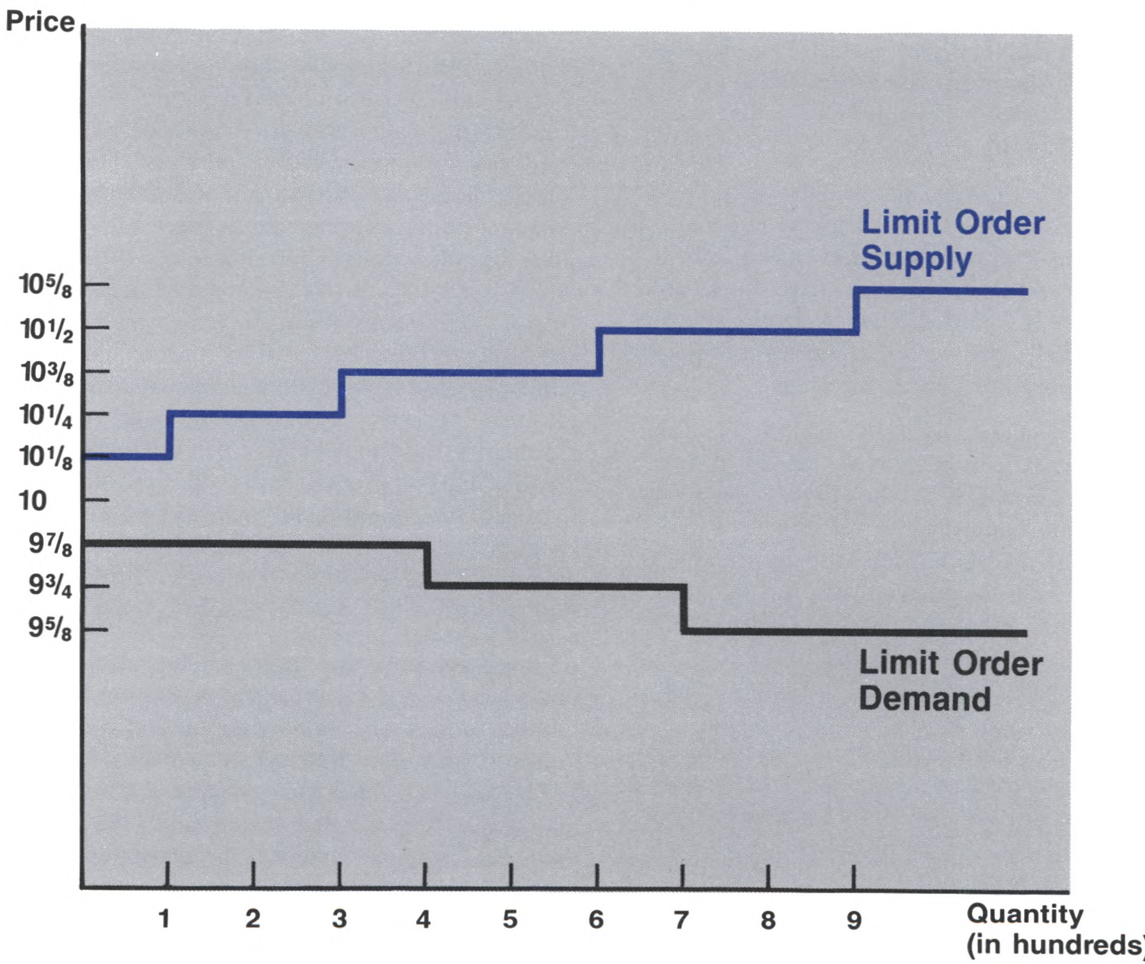
[20]See Grossman and Miller (1988) for a discussion of why trading rules many differ across the markets.

[21]Of course, the NYSE is not the only cash market for stocks, but it is a major market. Because of its relative size, the discussion focuses on this market.

[22]For purposes of exposition, the figure and discussion ignore the effect of "stops" and "stop loss orders" on the book.

[23]See Stoll (1985), Shultz (1946), pp. 119–44 and *The New York Stock Exchange Market* (1979), pp. 14–21 and pp. 30–31.

Figure 1
An Illustration of Limit Order Supply and Demand



one trade.[24] Similar reasoning applies to situations in which excess market sell orders exist at the quoted spread.

Notice that this process of "walking up" the supply curve or "walking down" the demand curve can generate a sequence of recorded transaction prices that run in the same direction. The larger the excess of market buy (or sell) orders is relative to the size of the specialist's limit orders at various prices, the longer the sequence of recorded transaction prices that run in the same direction and the greater the likelihood that recorded price changes over the time interval are correlated. This situation is particularly likely to arise during panics when large order imbalances develop at quoted prices.

Specialist Rule 104

Specialists are required by rule SR 104 to maintain a "fair and orderly" market. More specifically, the rule states that

> [t]he maintenance of a fair and orderly market implies the maintenance of price continuity with rea-

[24]Under NYSE rules, public orders have precedence over specialists' orders at the same price. See Stoll (1985), p. 7.

sonable depth, and the minimizing of the effects of temporary disparity between supply and demand.

In connection with the maintenance of a fair and orderly market, it is commonly desirable that a . . . specialist engage to a reasonable degree under existing circumstances in dealings for his own account when lack of price continuity, lack of depth, or disparity between supply and demand exists or is reasonably to be anticipated.[25]

For example, rule SR 104 requires the specialist to buy shares for his own account to assist the maintenance of an orderly market if, in his estimation, sell orders *temporarily* exceed buy orders at the existing market price and conversely. If these imbalances are truly temporary, the trades required by SR 104 will be profitable for the specialist; evidence indicates that specialists typically sell on up ticks in price and buy on down ticks.[26] If large order imbalances develop that threaten the orderliness of the market, the specialist may institute an opening delay or trading halt. The specialist needs the approval of a floor official or governor to do this and to establish a new opening price.[27]

The effect of SR 104 is to smooth what would otherwise be abrupt movements in stock prices, at least over short periods of time (a few minutes). Rather than allowing the price to move directly to some new level, specialist trading temporarily retards the movement. This can generate a sequence of correlated price changes.

Market-Making in the Futures Market

Trading in futures markets is governed by CFTC rules that require all trades of futures contracts to be executed openly and competitively by "open outcry." In particular, the trading arena, or pit, has no single auctioneer through whom all trades are funneled. Rather, the pit is composed of many traders who call out their bids and offers to each other. The traders are not required to stabilize the market. They may at any time take any side of a transaction even though this might add to an imbalance of buy and sell orders at the quoted price, and they may leave the pit (refuse to trade) at any time. At the time of the crash, there was no rule regarding limit moves in the price of the Standard and Poor's futures contract.

These rules contain no requirement to smooth out movements in the price. Traders are free to move the price immediately to a new level. Unlike the cash market, there are no trading rules in futures markets that are likely to result in correlated price changes. Furthermore, since there were no rules that retarded price changes in the futures market, futures prices were free to adjust more quickly than cash prices so changes in futures prices may lead changes in cash prices.

Different Instruments

It is important to note that different instruments are traded in the cash and futures markets. Stock index futures contracts are agreements between a seller (short position) and a buyer (long position) to a cash settlement based on the change in a stock index's value between the date the contract is entered by the two parties and some future date.[28] The instrument underlying the futures contract is a large basket of different stocks, that is, the stocks contained in the Major Market Index, the Value Line Index, the S&P 500 Index, etc. No such instrument is traded in the cash market, where purchasing or selling 500 different stocks, for example, requires as many different transactions and can only be executed at significantly higher costs.[29]

The different instruments traded in the cash and futures markets have a further implication for the relationship between observed price changes between the two markets. The cash market prices shown in chart 1, as well as those examined by the Brady Commission, are measured by an index. The index is an average of the prices of all the stocks included in the index. When the index is observed at a very high frequency (say, minute-by-minute), some of the stocks included in the index may not have traded during the interval between observations. If not, the level of cash prices measured by the index includes some prices from previous observations. In other words, the index

[25] *Report of the Presidential Task Force on Market Mechanisms* (1988), p. vi–7. Rule 104 is taken seriously. See pp. vi–9.

[26] See Stoll (1985), pp. 35–36.

[27] It was the application of SR 104 that resulted in the opening delays and trading halts that occurred during the week of October 19. For stocks included in the S&P 500, these delays and halts averaged 51 minutes on October 19 and 78 minutes on October 20. See U.S. General Accounting Office (1988), p. 56.

[28] See Schwarz, Hill and Schneeweis (1986), p. 9.

[29] For example, the cost of trading one futures contract based on the Standard and Poor's 500 is about $500 lower than trading the equivalent basket of stocks in the cash market. See Miller, Hawke, Malkiel and Scholes (1987), p. 11, and U.S. General Accounting Office (1988), p. 20.

Table 2

Stale Prices and Correlated Changes in a Price Index: A Simple Example

Period	Share prices A	B	C	Index[1]	Change in index
0	$10	$20	$30	100	
1	9	20	30	98.33	−1.67
2	9	18	30	95.00	−3.33
3	9	18	27	90.00	−5.00

[1]Index = $\frac{(A+B+C)/3}{\$20.00} \times 100$

includes some "stale" prices. The term used to describe this phenomenon is "nonsynchronous trading."

Typically, nonsynchronous trading does not create a serious measurement problem. Under normal conditions, a buy or sell order is executed in about two minutes on the NYSE. On October 16 and during the week of October 19, however, the time required to execute orders rose markedly.[30] On those days, the index contained a considerable number of stale prices.[31] The subsequent piecemeal adjustment of these stale prices for individual stocks could explain correlated changes in the level of the cash market index. This is shown in the table 2 example. The example assumes that the index is a simple average of the prices of three stocks (A, B and C) divided by the average price in period zero and multiplied by 100. The initial prices (in period zero) are equilibrium prices (i.e., they contain all currently available relevant information). Then, new information becomes available in period 1 that eventually will cause a 10 percent decline in all stock prices. If there is nonsynchronous trading, the revisions will occur piecemeal for each of the stocks. One example of this is shown in the table: the price of stock A falls in period 1, the price of stock B falls in period 2, etc. If the index is reported in each period, it will display positively correlated changes as shown in the table.

The stale price problem is not relevant for futures market prices; futures prices are actual prices. As a result, changes in futures prices will appear to lead changes in the cash market index if the index contains a substantial number of stale prices.

THE DIFFERENT IMPLICATIONS

The central feature of the cascade theory is that declines in cash and futures prices reinforced each other and led to further declines in both markets. The theory suggests that declines in the price of stock index futures contracts *caused* a decline in the cash prices of the underlying stocks, and this drop *caused* a further decline in the prices of index futures contracts. If the theory is correct, changes in cash prices will be positively correlated with past changes in the price of index futures and conversely. The cascade theory further implies that price changes in each market are positively correlated with their own past changes. This follows from the circularity of the theory which attributes sharp declines in stock prices to immediately preceding sharp declines. Finally, since the cascade theory contends that this specific behavior *caused* the panic, these correlations should be observed during the panic, but not at other times.

The efficient markets hypothesis suggests that market-making in the cash market and nonsynchronous trading could produce intra-day *cash* market price changes that are correlated. Furthermore, the hypothesis suggests that changes in futures prices may lead changes in cash prices. These implications are similar to the implications of the cascade theory. The two differ, however, in three important respects. Unlike the cascade theory, the efficient markets hypothesis suggests that:

(1) Changes in the price of stock index futures contracts are uncorrelated,

(2) Changes in cash prices do not lead changes in futures prices, and

(3) Relationships that exist across the two markets are not unique to the panic.

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[30]See U.S. General Accounting Office (1988), p. 73.

[31]See Harris (1988); *Report of the Presidential Task Force on Market Mechanisms* (1988), p. 30; Miller, Hawke, Malkiel and Scholes (1987), pp. 21–22 and 34–35; U.S. Commodity Futures Trading Commission (1988), pp. v, 15 and B-1 through B-9.

TESTING THE TWO THEORIES

These theories are tested using minute-by-minute data on the level of the Standard and Poor's 500 index (S&P 500) and the price of the December 1987 Standard and Poor's 500 index futures contract (S&P 500 Futures). The level of the S&P 500 index represents the cash price of the stocks underlying the S&P 500 futures contract. All tests are conducted using first differences of the natural logs of the levels. This transformation of the data approximates one-minute percentage changes (expressed in decimals) in cash and futures market prices. The data cover the trading days immediately before, during and after the panic: October 16, 19 and 20.[32]

A few comments about the data are important. The NYSE, on which the great bulk of the stocks included in the S&P 500 index are traded, was open from 9:30 a.m. to 4:00 p.m. EST on the above days. The CME, which trades the S&P 500 futures contract, was open from 9:30 a.m. to 4:15 p.m. EST on October 16 and 19; on October 20, however, trading in the S&P 500 futures contract was halted from 12:15 p.m. to 1:05 p.m. EST. All tests reported here *exclude* the period on October 20 when trading in the futures market was halted.

Were Changes in Stock Prices Correlated?

Table 3 presents the results of a test (called a Box-Pierce test) based on the estimated autocorrelations of percentage changes in cash market prices. This test is designed to determine whether the data are significantly correlated, that is, whether current changes in cash market prices are related to their own past changes. Both theories discussed in this paper suggest that intra-day, high-frequency cash market price changes will be positively correlated, although the reasons for the positive correlation are considerably different. As a result, these data do not help discriminate between the two theories. If the data prove inconsistent with this implication, however, neither theory performs well in explaining the behavior of cash market prices.

The data in table 3 indicate that minute-to-minute changes in the S&P 500 Index are significantly correlated. Furthermore, the correlations are positive at least over the initial lag.[33]

Table 3

Cash Market (Autocorrelation Coefficients and Box-Pierce Statistics for First Differences of Logs of the Minute-by-Minute S&P 500 Index)

Panel A: October 16, 1987 (9:30 a.m. – 4:00 p.m. EST)

To lag	Autocorrelation coefficient	Box-Pierce statistic[1]
1	.570*	112.09
2	.530*	209.00
3	.385*	260.14
6	.178*	333.81
12	−.148	352.51
18	−.208	406.39
24	−.072	462.80

Panel B: October 19, 1987 (9:30 a.m. – 4:00 p.m. EST)

To lag	Autocorrelation coefficient	Box-Pierce statistic[1]
1	.342*	37.78
2	.397*	88.69
3	.406*	141.93
6	.264*	237.78
12	.231*	345.66
18	.124	385.52
24	.054	396.34

Panel C: October 20, 1987 (9:30 a.m. – 4:00 p.m. EST)

To lag	Autocorrelation coefficient	Box-Pierce statistic[1]
1	.535*	84.15
2	.561*	176.68
3	.590*	279.02
6	.521*	548.61
12	.311*	845.55
18	.324*	1026.74
24	.250	1155.57

[1]Critical value for 24 lags is 33.20. A Box-Pierce statistic in excess of this indicates significant autocorrelation.

*Exceeds two standard errors

Table 4 presents the results of the same test for the December S&P 500 futures contract. The efficient markets hypothesis and the absence of specialist traders suggest that these changes are not correlated. Conversely, the cascade theory

[32]Minute-by-minute price data were also examined for October 15 and 21–23. In each case, the qualitative results were the same as those presented here.

[33]These correlations are analyzed further below.

Table 4

Futures Market (Autocorrelation Coefficients and Box-Pierce Statistics for First Differences of Logs of the Minute-by-Minute Price of the December S&P 500 Futures Contract)

Panel A: October 16, 1987 (9:30 a.m. – 4:15 p.m. EST)

To lag	Autocorrelation coefficient	Box-Pierce statistic[1]
1	.090	2.89
2	.035	3.33
3	–.047	4.12
6	–.020	8.25
12	–.020	16.02
18	.017	19.10
24	–.044	22.29

Panel B: October 19, 1987 (9:30 a.m. – 11:00 a.m. EST)

To lag	Autocorrelation coefficient	Box-Pierce statistic[1]
1	–.309*	8.49
2	.140	10.24
3	.005	10.24
6	–.131	15.41
12	.110	18.95
18	.043	21.69
24	–.020	23.13

Panel C: October 19, 1987 (11:00 a.m. – 4:15 p.m. EST)

To lag	Autocorrelation coefficient	Box-Pierce statistic[1]
1	–.072	1.63
2	.090	4.17
3	–.004	4.18
6	.091	7.21
12	.020	9.60
18	.073	14.95
24	.000	22.37

Panel D: October 20, 1987 (9:30 a.m. – 4:15 p.m. EST)

To lag	Autocorrelation coefficient	Box-Pierce statistic[1]
1	.029	.26
2	.022	.41
3	.042	.95
6	.046	4.22
12	–.071	9.28
18	.033	11.81
24	–.035	17.62

[1]Critical value for 24 lags is 33.20. A Box-Pierce statistic in excess of this value indicates significant autocorrelation.
*Exceeds two standard errors

predicts that percentage changes in the futures price will be positively correlated.

The data presented in table 4 are consistent with the efficient markets hypothesis, not the cascade theory. None of the test statistics for October 16 (panel A), October 20 (panel D) and for the bu!k of the trading day on October 19 (panel C) indicate significant correlations at conventional significance levels. These price changes are serially uncorrelated.[34] Data for the first 90 minutes of trading on October 19 (panel B) are an exception. During this period, changes in the futures price were significantly correlated with the change the previous minute. This correlation, however, is negative, not positive as the cascade theory implies.[35] Thus, the evidence presented in table 4 is inconsistent with the cascade theory, while, on the whole, it conforms to the efficient markets hypothesis.

Is the Cash Market Efficient?

The table 3 results indicate that intra-day changes in cash market prices are correlated. Put another way, past price changes contain some information about future changes for the next few minutes. Is this information useful in the sense that it can be profitably exploited by traders? If so, it would suggest that cash market traders do not incorporate information efficiently. This, of course, would provide evidence against the efficient markets hypothesis.

In part, the answer to this question depends on the length of the time period over which the price changes are related. If the time period is short, shorter than the time required to execute a transaction, the information contained in past price changes cannot be exploited profitably and the cash market is efficient.

Table 5 helps answer this question. The table 5 data are estimates of the length of the lagged relationship between current and past cash market price changes for October 16, 19 and 20. The estimates were obtained by regressing the contemporaneous minute-to-minute price change on the 15 previous minute-to-minute price changes. Initially, this specification was identified as the unrestricted model. To determine whether the esti-

[34]The same result was obtained when data for October 15 and 21–23 were examined.

[35]This puzzling result for the first 90 minutes of trading on October 19 may be due to the fact that many stocks had not yet opened for trading on the NYSE and the rumors at that time that the SEC would call a trading halt. See Miller, Hawke, Malkiel and Scholes (1987), wire report summary.

Table 5
Estimated Lag Lengths in the Cash Market

Panel A: October 16, 1987 (9:30 a.m. – 4:00 p.m. EST)

$$\Delta LNC_t = \underset{(1.19)}{-.003} + \underset{(7.80)^*}{.401}\Delta LNC_{t-1} + \underset{(6.51)^*}{.343}\Delta LNC_{t-2}$$

$\bar{R}^2 = .41$
DW = 2.00

Panel B: October 19, 1987 (9:30 a.m. – 4:00 p.m. EST)

$$\Delta LNC_t = \underset{(2.46)^*}{-.016} + \underset{(2.20)^*}{.123}\Delta LNC_{t-1} + \underset{(4.14)^*}{.228}\Delta LNC_{t-2} + \underset{(4.39)^*}{.242}\Delta LNC_{t-3} + \underset{(1.99)^*}{.112}\Delta LNC_{t-4}$$

$\bar{R}^2 = .26$
DW = 2.01

Panel C: October 20, 1987 (9:30 a.m. – 4:00 p.m. EST)

$$\Delta LNC_t = \underset{(.132)}{-.001} + \underset{(1.82)}{.107}\Delta LNC_{t-1} + \underset{(2.98)^*}{.173}\Delta LNC_{t-2} + \underset{(4.52)^*}{.258}\Delta LNC_{t-3} + \underset{(2.99)^*}{.174}\Delta LNC_{t-4} + \underset{(2.60)^*}{.153}\Delta LNC_{t-5}$$

$\bar{R}^2 = .48$
DW = 2.02

*Statistically significant at the 5 percent level

mated coefficients are sensitive to the lag length and to identify statistically redundant lags, the lag structure was successively shortened by one lag. At each stage, the t-statistic for the coefficient of the most distant lag was examined. If the test indicated the coefficient was statistically insignificant, that lag was dropped and the equation was reestimated with one less lag. This process was repeated until the test rejected the hypothesis that the estimated coefficient of the most distant remaining lag was zero.[36]

The estimates shown in table 5 indicate that the lags ranged from about two minutes on October 16 to five minutes on October 20.[37] It requires about two minutes to execute a trade on the NYSE under normal trading conditions. During the panic, execution times ranged from about 10 to 75 minutes at times.[38] In view of this, the lags estimated in table 5 do not appear to be long enough to reject the efficient markets hypothesis; also, since they varied over the period, it is doubtful that past price changes contained information that could be exploited by traders.

Did Stock Price Changes Reinforce Each Other Across Markets?

The central feature of the cascade theory can be tested by determining whether past price changes in the futures market help explain current price changes in the cash market and conversely. This is done by regressing the change in cash prices on past changes in cash prices; then, past changes in futures prices are added to the estimated regression equation to see if they improve the equation's explanatory power. An F-test is conducted to determine whether the addition of the futures market data significantly increases the cash price equation's coefficient of determination (R^2). The

[36]See Anderson (1971), pp. 223 and 275–76. It is possible that this test may reject some lags that are, in fact, significant if taken as a group. To control for this, F-tests were run with the lag length in the unrestricted model set at 15. The number of lags in the restricted model was set at 12 to determine if the three omitted lags were significant. The lags in the restricted model was then reduced to nine and the test repeated, etc.

[37]The lag had declined to about three minutes by October 23. The method used in this paper to estimate lag length has the problem that the probability of rejecting the null hypothesis (the estimated coefficient is zero) when it is true rises as the lag length is reduced. Consequently, the true lag lengths may be shorter than those estimated in table 5. See Batten and Thornton (1983), pp. 22–23, and Anderson (1971), pp. 30–43.

[38]U.S. Government Accounting Office (1988), p. 73.

Table 6
Granger Tests

Day	Lags	F-statistic Futures → Cash	F-statistic Cash → Futures
October 16	2	17.61*	.76
October 19	4	4.46*	1.57
October 20	5	2.59*	.67

*Statistically significant at the 5 percent level

test is then reversed, with the change in futures prices as the dependent variable.

The results of this test are presented in table 6 for each of the trading days examined in this paper. The lag length employed on each day is the one identified by the table 5 test.[39] The results for cash market prices show that the addition of past changes in futures prices improve the regression estimates; this suggests that price changes in the futures market preceded those in the cash market. This result is consistent with both the cascade theory and the efficient markets hypothesis. Furthermore, it is not unique to the panic; it has been observed for intra-day price data during other periods as well.[40]

Other table 6 results, however, are inconsistent with the cascade theory. The inclusion of past changes in cash prices in the regressions that estimate the change in futures prices does not significantly improve the estimates. This rejects the notion that past changes in cash prices help explain changes in futures prices. This finding is inconsistent with the central feature of the cascade theory, which suggests the panic was caused by declines in cash and futures prices that became larger as they tumbled over each other on the way down.

CONCLUSION

This paper has examined the cascade theory, which has been advanced as an explanation of the October 1987 stock market panic. The theory relies on the notion that stock traders behave "mechanically," are "insensitive to price," and execute transactions in markets without regard to transaction costs. These assertions are inconsistent with the behavior of wealth-maximizing individuals. Not only are the theoretical underpinnings of the cascade theory weak, the data do not support the theory. Instead, the observed relationships that do exist between the markets are not unique to the crash and can be explained by a theory that relies on wealth maximizing behavior.

Almost 60 years later, the cause of the "Great Crash" in October 1929 is still being debated. Those with even longer memories know that there is little agreement about what caused the stock market panic in 1907. Although financial reforms followed each of these panics, history indicates that the reforms have done little to reduce the frequency or severity of panics. Without a reliable theoretical guide to the mechanics of a panic, any reform is no more than a "shot in the dark." The evidence presented in this paper suggests that the reforms advanced by proponents of the cascade theory are unlikely to alter this historical pattern.

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[39]Hsiao (1981) uses a similar method. These lag lengths apply to the cash market. Analysis of the futures market suggests that the appropriate lag for this market is zero.

[40]See Kawaller, Koch and Koch (1987).

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The Competitive Nature of State Spending on the Promotion of Manufacturing Exports

THE expansion of jobs and incomes is a leading priority of state governments. An increasingly popular view is that economic growth can be stimulated by increasing the amount of manufactured goods that are sold by firms in a state to consumers and producers in foreign countries. To accomplish this, many states have devoted more resources to the promotion of manufactured exports abroad. Very little, however, is known about the effects of this economic development effort.

Research by Coughlin and Cartwright (1987) found a positive relationship between a state's exports and its promotional expenditures. A related issue, the focus of this study, is whether a state's exports are affected by the promotional expenditures of other states.[1] Are the effects of a state's promotional efforts being counteracted by the expenditures of other states? On the other hand, are the promotional expenditures of other states increasing export demand overall, thereby increasing a state's exports?

This paper begins with an overview of state export promotion expenditures and programs. The subsequent analysis consists of developing and estimating a model of state-manufactured exports for 1980 that includes standard international trade variables as well as export promotion expenditures.[2] A summary of the primary results completes the study.

STATE GOVERNMENT EXPORT PROMOTION

Manufactured exports are an important source of jobs for many state economies. In 1984, the most recent year of estimates in the *Annual Survey of Manufactures*, more than 500,000 jobs in Califor-

[1]A similar issue arises as states compete for foreign direct investment. This issue is illustrated in an anecdote from Prestowitz (1988). The author, then a Department of Commerce specialist on U.S.-Japanese trade, was asked to brief a group of Kentucky congressmen on Japan. The briefing occurred shortly after Toyota had announced its plans to build an assembly plant in Kentucky, and the congressmen were hoping to attract Japanese parts suppliers with various incentives. Prestowitz asked whether they realized that for every Japanese plant that opened in Kentucky, an American one in Michigan was likely to close. "We're not the congressmen from Michigan," was their reply. While one might question Prestowitz's assertion about the effects on Michigan of attracting a parts supplier to Kentucky, the motivation of the Kentucky congressmen is clear. Their goal is to stimulate economic activity in Kentucky with, at most, minimal regard for its consequences elsewhere.

[2]While some of the data in this study are available for more recent years than 1980, the more recent data are not as complete. For example, more states supplied figures for export promotion in 1980 than in recent years. A second reason for using 1980 is a desire to compare the current results using the export equation with previous research.

nia, 5.5 percent of private-sector employment, were due to manufactured exports. Though California led the nation in the number of jobs involved, numerous states were relatively more dependent on manufactured exports for jobs. The percentage of private-sector employment due to manufactured exports exceeded 7 percent for Connecticut and 6 percent for Indiana, Massachusetts, Michigan, Ohio and Washington.[3]

Not surprisingly, states have tried to increase their manufactured exports.[4] State governments provide resources for trade missions and catalog shows. Many maintain overseas offices to provide basic information to potential foreign customers about goods and services available from state firms. The information available through some state governments (for example, New York) has been expanded by the development of computerized information systems concerning trade opportunities. Some state governments (for example, Illinois and Arkansas) are also becoming increasingly involved in providing financial assistance to exporters. Finally, a number of states are either developing their own export trading companies (for example, New York/ New Jersey and Virginia) or assisting private firms using export trading companies. Due to the alleged cost disadvantages faced by small firms, these state services tend to be geared to small rather than large businesses.

Before 1980, evidence on state export promotional expenditures is scarce. Albaum (1968) reported sketchy budget information on 36 states (16 of which had no specific budget) for 1967. The most complete budgetary data for all states was compiled by Berry and Mussen (1980), who reported state export promotion expenditures of approximately $18.9 million during 1980. These expenditures reflected an average state expenditure of $377,111.

Due to the complexity of allocating state budget expenditures to export promotion, these figures are likely to represent a lower bound. For example, although the figures include the salaries of personnel explicitly tied to export promotion, the salaries of state government officials such as governors who spend much time and effort promoting exports are not included in these figures. One might also include the salaries of personnel at state universities involved in export promotion as well as the costs associated with providing financial assistance to exporters. Given the small size of the reported state expenditures, these omissions could be relatively important.

Table 1 presents the state export promotion data used in this analysis. Export promotion, which is a very small share of a state's total expenditures, ranged from zero for Utah to more than $1.8 million for Ohio. Illinois, Virginia and Maryland joined Ohio in spending more than $1 million to promote exports.

To take into account the differences among states in terms of their populations, the export promotion figures in table 1 are also presented on a per capita basis. The median expenditure is slightly in excess of 5 cents. On a per capita basis, Alaska is far and away the leading state. Alaska's expenditure of 93 cents per resident is more than 2 1/2 times the per capita expenditure of Montana, the second-leading state. Although neither Alaska (13) nor Montana (18) were among the leading states on a total expenditures basis, those that were, were also among the leading states on a per capita basis. Ohio, Illinois, Virginia and Maryland were ranked 6, 12, 4 and 3, respectively, on a per capita basis.

The limited evidence, which mixes expenditures to attract foreign direct investment with export promotion, suggests that export promotion expenditures are increasing rapidly. Berry and Mussen (1980) reported that average state expenditures for the promotion of international business increased by a factor of four between 1976 and 1980 for a sample of 25 states that supplied adequate data. Figures from the National Association of State Development Agencies (1986) indicate that such expenditures increased by two-thirds between 1984 and 1986.

A MODEL OF STATE EXPORTS

In this section, a model of state exports is presented and estimated. The model incorporates the standard variables used in international trade studies along with export promotion variables. The empirical results shed some light on the effect of a state's promotional expenditures on its ex-

[3]Between 1980 and 1984, the relative importance of manufactured exports for jobs declined; however, recent increases in U.S. exports suggest that this decline has been reversed.

[4]Barovick (1984) and Ouida (1984) can be consulted for details about the proliferation of export activities.

Table 1
1980 State Export Promotion Expenditures

State	Total: Export Promotion	Total: Rank	Per Capita: Export Promotion	Per Capita: Rank
Alabama	$ 273,750	19	$.0709	22
Alaska	372,500	13	.9306	1
Arizona	107,200	32	.0395	34
Arkansas	175,000	27	.0767	20
California	234,224	23	.0100	45
Colorado	120,120	30	.0417	33
Connecticut	75,000	37	.0242	38
Delaware	30,000	43	.0504	27
Florida	458,280	12	.0478	29
Georgia	310,050	17	.0575	24
Hawaii	107,250	31	.1112	14
Idaho	47,500	40	.0048	49
Illinois	1,527,060	2	.1349	12
Indiana	752,042	7	.1379	11
Iowa	240,273	22	.0826	16
Kansas	70,000	38/39	.0297	37
Kentucky	576,810	10	.1584	7
Louisiana	25,000	44	.0060	48
Maine	90,740	35	.0807	19
Maryland	1,287,319	4	.3070	3
Massachusetts	45,000	41	.0079	46
Michigan	682,000	9	.0738	21
Minnesota	188,000	26	.0462	30
Mississippi	150,000	28	.0599	23
Missouri	729,000	8	.1487	9
Montana	277,632	18	.3542	2
Nebraska	195,711	24	.1251	13
Nevada	5,000	49	.0063	47
New Hampshire	20,000	45	.0218	40
New Jersey	315,000	16	.0429	31
New Mexico	70,000	38/39	.0542	25
New York	845,000	5	.0484	28
North Carolina	503,500	11	.0861	15
North Dakota	99,960	34	.1533	8
Ohio	1,832,800	1	.1704	6
Oklahoma	247,604	21	.0826	17
Oregon	361,767	14	.1382	10
Pennsylvania	263,285	20	.0223	39
Rhode Island	11,250	47	.0120	44
South Carolina	100,000	33	.0326	35
South Dakota	139,200	29	.2024	5
Tennessee	193,644	25	.0427	32
Texas	739,794	6	.0523	26
Utah	0	50	.0000	50
Vermont	6,825	48	.0133	43
Virginia	1,487,187	3	.2795	4
Washington	333,000	15	.0810	18
West Virginia	35,773	42	.0186	41
Wisconsin	82,500	36	.0176	42
Wyoming	15,000	46	.0320	36

SOURCE: Berry and Mussen (1980) in *Export Development and Foreign Investment: The Role of the States and Its Linkage to Federal Action.*

ports as well as the effect of export promotion by other states on a selected state.

The Heckscher-Ohlin approach to international trade, developed by two Swedish economists, Eli Heckscher and Bertil Ohlin, highlights the importance of a country's productive resources in determining its pattern of international trade.[5] Goods are traded internationally because of differences in production costs. These differences depend on the proportions in which factors of production exist in different countries (that is, the relative factor endowments) and how the factors are used in producing different goods (that is, the relative factor intensities).

An example can be used to illustrate the Heckscher-Ohlin theory. Assume two countries, the United States and Mexico, two factors of production, capital and labor, and two goods, airplanes and cloth. In a two-factor world, a country is capital-abundant (labor-abundant) if it is endowed with a higher (lower) ratio of capital to labor than the other country. Assume the United States is capital-abundant and Mexico is labor-abundant. In a two-good world, a product is capital-intensive if its production requires a relatively higher ratio of capital to labor than the other good. Assume airplanes are capital-intensive and cloth is labor-intensive. The Heckscher-Ohlin theory predicts that a country will export the good that uses its abundant factor intensively and import the other good. The reason for this trade pattern hinges on the relative production costs. A country should be able to produce the good that uses relatively larger amounts of its abundant resource at a lower cost. Thus, the United States should export airplanes to Mexico and import cloth from Mexico.

The Heckscher-Ohlin approach allows for predictions about trade patterns based on knowledge of countries' factor supplies. Since the services of factors of production are embodied in exports and imports, international trade may be viewed as the exchange of the services of the country's abundant factor for the services of the country's scarce factor. In the example, the United States exports the services of its abundant factor, capital, and imports the services of its scarce factor, labor. A common summary statement is that capital is a source of comparative advantage for the United States, while labor is a source of comparative disadvantage.

The preceding idea can be applied to regions within a country. In Coughlin and Fabel (forthcoming), a Heckscher-Ohlin approach was developed to examine the export performance of individual states. The international exports of a state (EX) are defined as the value of manufactured direct exports for 1980.[6] A state's endowment of manufacturing resources determines its international competitiveness. Relying upon a standard Heckscher-Ohlin framework, a three-factor model with physical capital (K), human capital (H) and labor (L) is used. Thus, a state's exports are related to its relative endowment of these manufacturing resources. A state with larger amounts that are sources of U.S. comparative advantage (disadvantage) will have more (less) exports.

Whether physical capital is a source of U.S. comparative advantage has been a controversial topic since Leontief's (1954) surprising finding that the U.S. exported labor-intensive rather than capital-intensive goods. This continuing controversy is irrelevant for the current research.[7] To reflect the controversy, the expected impact of physical capital, measured by the gross book value of a state's depreciable manufacturing assets, is uncertain.[8]

Stern and Maskus (1981), as well as many others, have concluded that human capital is a source of U.S. comparative advantage. Thus, increases in a state's endowment of human capital, *ceteris paribus*, are expected to be related positively to state export performance. The calculation of a state's endowment of human capital, following Hufbauer (1970), attributes the difference between a state's

[5]Additional details on the Heckscher-Ohlin theory can be found in Krugman and Obstfeld (1988) or any other introductory international trade text.

[6]Unless noted otherwise, the data were taken from various issues of the *Annual Survey of Manufactures*.

[7]The bulk of cross-industry studies have found physical capital to be a scarce factor (Baldwin, 1971; Branson and Junz, 1971; Sailors, Thomas and Luciani, 1977; Stern and Maskus, 1981); however, the deficiencies of these studies have been highlighted by Leamer and Bowen's (1981) demonstration that inferences about factor abundance were not strictly justified and by Aw's (1983) identification of the highly restrictive conditions that are necessary to justify the inferences. Research by Bowen (1983) and by Coughlin and Fabel (forthcoming), which were designed to avoid the criticisms of cross-industry studies, suggests that physical capital is a source of U.S. comparative advantage.

[8]The use of the gross book value of depreciable assets as a measure of physical capital is not ideal. As Browne et al. (1980) have indicated, this measure is derived from accounting practices rather than economics. Consequently, it might not be a good measure of productive capacity. This problem is partially mitigated by the cross-section nature of the current analysis because relative productive capacity rather than absolute capacity is of primary importance.

average annual pay in manufacturing and the median pay of persons with zero to eight years of education as a return to human capital.[9] This return is multiplied by the number of manufacturing employees to generate a measure of total returns to human capital in manufacturing. A state's endowment of human capital is the capitalized (at 10 percent) value of these total returns.

A standard research finding reconfirmed recently by Stern and Maskus (1981) is that labor, measured as the number of manufacturing employees in a state, is a relatively scarce factor in the United States. If this factor is a source of U.S. comparative disadvantage, then increases in a state's endowment of labor, holding physical and human capital constant, should be related negatively to the state's exports.

In addition to a state's endowment of physical capital, human capital and labor, export promotion expenditures are expected to affect manufacturing exports from a state positively. The export promotion figures cited in table 1 encompass expenditures for the promotion of manufactured and agricultural goods. Since this study focuses on manufactured exports, the use of total export promotion expenditures might introduce some error into the estimations. Unfortunately, the magnitude of agricultural export promotion at the state level is unknown.

Berry and Mussen (1980) reported that the Department of Agriculture in 26 states received funds for export promotion. Since agricultural exports could be promoted by other administrative units, agricultural export promotion is not necessarily restricted to these states. To approximate total expenditures for manufacturing export promotion, total export promotion expenditures were multiplied by the ratio of manufacturing employees to the sum of manufacturing and full-time agricultural employees. This new measure is designated as PROM.[10]

Estimation Results

Assuming a linear function, the preceding model can be represented as

$$(1)\quad EX = d_0 + d_1K + d_2H + d_3L + d_4PROM + e,$$

where the d's are the parameters to be estimated and e is the disturbance term. The model was estimated using generalized least squares because the residuals using ordinary least squares indicated heteroscedasticity.[11] The results, which were also reported in Coughlin and Cartwright (1987), are listed under variant #1 in table 2.[12] The results indicate that both physical and human capital are positive, statistically significant determinants of state manufacturing exports. The remaining endowment variable, labor, is not statistically significant.

For present purposes, the positive impact of export promotion expenditures is the key result; however, the statistical significance of this variable hinges on whether a 5 percent or 10 percent significance level is chosen.[13] The point estimate indicates that manufacturing exports, on average will increase by .432 for a one-unit increase in manufacturing export promotion expenditures. Since export promotion expenditures are measured in thousands of dollars and exports are measured in millions of dollars, an increase in export promotion expenditures of $1000 is estimated to increase exports by $432,000.

This estimate seems much too large and, in fact, there are reasons to think the estimate is biased

[9]This calculation of human capital has been used frequently in international trade studies. It should be noted that the difference between average annual pay in manufacturing and the pay of persons with zero to eight years of education might not be entirely a return to human capital. For example, the market power of unions might increase wages in manufacturing; however, the inclusion of a state unionization variable did not affect the impact of human capital and was not statistically significant.

[10]Two other adjustments to total export promotion expenditures were examined; these adjustments did not alter the empirical results. Total export promotion expenditures were multiplied by: (1) the percentage of a state's population that did not live on farms; and (2) the ratio of manufacturing employees to the sum of manufacturing and total agricultural employees. Total export promotion expenditures were found in Berry and Mussen (1980). The adjustment factors to develop estimates of manufacturing export promotion expenditures were taken from the *Statistical Abstract of the United States* (farm population figures) *and the Census of Agriculture* (agricultural employment figures).

[11]Following Glejser (1969), the weights for the observations are determined by a two-step procedure. First, the residuals from an ordinary least squares regression of equation 1 are generated. Second, the inverses of the weights are generated by a linear function using total state employment as the determinant of the absolute value of the residuals from the first step. See Fomby et al. (1984), pp. 180–82, for details.

[12]Since Washington was uncharacteristic in the sense that the actual value of exports was exceptionally large relative to its predicted value, it was dropped from the estimation.

[13]It should be noted that export promotion expenditures likely have important investment aspects. The results of current export promotion expenditures will not necessarily occur immediately. Consequently, export promotion expenditures in 1980 will affect exports in future periods as well as the current period, and exports in 1980 were likely affected by previous export promotion expenditures. Because of absence of sufficient time-series data on export promotion, this lag structure could not be estimated.

Table 2

Export Promotion Variants of 1980 State Export Functions

Dependent Variable: EX′

Independent Variables	GLS Parameter Estimates (t-ratios)				
	Variant #1	Variant #2	Variant #3	Variant #4	Variant #5
Intercept	−8.503	−4.281	23.343	−54.725	−56.837
	(−0.15)	(−0.07)	(0.32)	(−0.98)	(−1.04)
K′	9.259*	12.677*	11.994*	9.330*	9.476*
	(3.81)	(3.88)	(3.78)	(3.99)	(4.12)
H′	39.173ᵃ	42.654ᵃ	52.735ᵃ	37.632ᵃ	37.054ᵃ
	(2.19)	(2.39)	(2.13)	(2.18)	(2.18)
L′	7.730	5.922	3.895	12.633	13.408
	(0.60)	(0.41)	(0.02)	(0.89)	(0.96)
PROM′	0.432	0.354	0.436ᵃ	−0.001	−0.119
	(1.65)	(1.36)	(1.72)	−(0.00)	(−0.36)
RP-Census′				14.388*	
				(2.36)	
RP-Cluster′					24.651*
					(2.66)
TP-Census′		−0.646			
		(−0.69)			
TP-Cluster′			−1.297		
			(−0.83)		

* statistically significant at the .05 level (two-sided)

a statistically significant at the .05 level (one-sided)

′ The variables are defined in the text and are measured as follows: EX – millions of dollars; K and H – hundred millions of dollars; L – ten thousands of employees; PROM – thousands of dollars; TP-Census and TP-Cluster – numerator is in millions of dollars and denominator is the number of states; and RP-Census and RP-Cluster – numerator and denominator are in cents per capita.

upward. First, as mentioned previously, the reported state budget expenditures on export promotion are likely a lower bound. To the extent these figures are understated, the coefficient estimate will be overstated. For example, if the export promotion expenditures are understated by 50 percent, the coefficient estimate should be halved. Second, the model does not control for either private or other governmental export promotion expenditures. To the extent that these other export promotion expenditures are correlated with state expenditures, the coefficient estimate is biased upward. Finally, due to the lack of data, there is no lag structure in the model. Consequently, while export promotion expenditures and exports are positively related, the point estimate is likely unreliable.

Cross-State Effects

Attention can now be focused upon whether there are externalities associated with export promotion. If these externalities exist, they could be positive or negative. Export promotion expenditures by other states might increase export demand generally and produce additional exports from the state in question. On the other hand, perhaps a substitution effect exists; increases in export promotion expenditures by one state will reduce the exports of other states.[14] In this case, a state may be forced into promotional efforts as an act of self-defense.

Ascertaining the existence of externalities is neither easy nor straightforward. The preceding

[14]Even though a state's exports may be affected adversely by the export promotion expenditures of competitive states, the state may not necessarily incur short-run employment losses because the export demand reduction could be offset by increased domestic demand.

paragraph focuses on the notion of competitive export goods; however, the dependent variable is total state exports. Given this aggregation, the idea of competitive exports must be transformed into competitive states. For example, it is difficult to envision how export promotion by South Carolina would affect Alaska; it is not difficult, however, to envision how export promotion by South Carolina would affect North Carolina. The notion of competitive states was developed in two ways. First, states were viewed as competitive if they belong to the same census region.[15] Since geography is a key feature of this categorization, an attempt to classify states on the basis of certain economic characteristics was made. The results reported in variant #1 in table 2 reflect the fact that states have different sources of comparative advantage. Competitive states should be those states whose sources of comparative advantage (that is, resource endowments) are similar. A cluster analysis was performed that grouped states into seven clusters based on their ratios of physical capital to labor and human capital to labor.[16]

After the states were grouped, the next step was to construct reasonable variables to test for externalities. There are numerous reasonable candidates. The difficulty arises because of the necessity of scaling the promotional expenditures of competitive states. For example, assume two groups of states, one containing five states and the other three states. The goal of the regression analysis is to indicate the impact upon a member of a group when promotional expenditures by another member (or members) increase. It seems reasonable that the larger the group the smaller the impact on any individual member of increased expenditures by another member. The effect is lessened because it is spread over more states. A straightforward approach is to divide the total promotional expenditures of competitors by the number of competitors. These variables are designated as TP-Census and TP-Cluster. The existence of a positive impact of a region's export promotional expenditures will be revealed by a positive sign for the TP variables, while a negative impact will be revealed by a negative sign.

Another approach to test for externalities is to use a state's spending on export promotion relative to the spending of its competitors. Scaling the promotional expenditures of a state relative to its competitors is accomplished by dividing both expenditures by their respective populations.[17] These variables are designated as RP-Census and RP-Cluster. If a region's per capita export promotion expenditures increase, *ceteris paribus*, then the ratio of state to region per capita export promotion expenditures will decline. Consequently, the existence of a positive impact of a regions's export promotion expenditures will be revealed by a negative sign for the RP variables, while a negative impact will be revealed by a positive sign.

Variants #2 and #3 in table 2 highlight the effect of adding TP-Census and TP-Cluster to the basic model, while variants #4 and #5 highlight the effect of adding RP-Census and RP-Cluster. The

[15]The nine census regions are as follows: New England — Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont; Middle Atlantic — New Jersey, New York and Pennsylvania; East North Central — Illinois, Indiana, Michigan, Ohio and Wisconsin; West North Central — Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota; South Atlantic — Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia and West Virginia; East South Central — Alabama, Kentucky Mississippi and Tennessee; West South Central — Arkansas, Louisiana, Oklahoma and Texas; Mountain — Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming; and Pacific — Alaska, California, Hawaii, Oregon and Washington.

[16]The clusters were generated using the CLUSTER procedure in SAS. The purpose of cluster analysis is to group objects such that those in a given cluster tend to be similar to each other in some sense while those in different clusters tend to be dissimilar. In the present case, states with similar ratios of physical capital to labor and human capital to labor were grouped together. The procedure, described on pages 423 and 424 in the *SAS User's Guide: Statistics* (1982), begins with each observation (i.e., state) as a cluster by itself. Next, the two closest clusters are combined to form a new cluster. This merging continues until only one cluster remains. There are different clustering algorithms with the distinguishing feature being how the difference between two clusters is measured. In Ward's method, which was the specific algorithm used, the distance between two clusters is the sum of squares between the two clusters over all clusters. At each step, the within-cluster sum of squares is minimized over all the possibilities obtainable by merging two clusters from the previous step. This method was used to reduce the original 49 clusters until there were the following seven groups: (1) California, New York, Connecticut and New Jersey; (2) Arizona, Missouri, Oklahoma, Utah, Wisconsin, Massachusetts, Minnesota, Colorado, Oregon, Pennsylvania, Maryland and Nevada; (3) Indiana, Delaware, Ohio, Illinois, Washington and Michigan; (4) Alabama, Idaho, North Dakota, Hawaii, Kentucky, Iowa and New Mexico; (5) Florida, Tennessee, Georgia, Kansas, Virginia, New Hampshire and Rhode Island; (6) Arkansas, Maine, South Carolina, Mississippi, Nebraska, North Carolina, Vermont and South Dakota; and (7) Texas, West Virginia, Wyoming, Alaska, Louisiana and Montana.

[17]The ratio of state to region per capita export promotion expenditures was selected rather than the ratio of region to state because of Utah's zero value for export promotion. This complicates the interpretation of the variable, but was unavoidable.

only unqualified conclusion is that there is no substantial impact on the statistical results for the factor endowment variables. The remaining conclusions must be qualified.

The results, while similar for both groupings of competitive states, are sensitive to which method is used to control for externalities. The results for each variant indicate that increases in promotional expenditures by competitors, *ceteris paribus*, are associated with a reduction in a state's exports; however, the results are not strong. Total promotional expenditures divided by the number of competitors in variants #2 and #3 is not a statistically significant determinant of state exports, while state per capita promotional expenditures divided by competitors' per capita promotional expenditures in variants #4 and #5 is a statistically significant determinant. In addition, the impact of adding the variable to control for externalities has different effects on the export promotion variable (PROM). The t-ratios are roughly similar in variants #2 and #3 compared to variant #1. In fact, in variant #3 PROM is statistically significant. On the other hand, in variants #4 and #5 the t-ratio for PROM is virtually zero.

SUMMARY

The results, which should be viewed as tentative because of the acknowledged data limitation, highlight the effects of export promotion expenditures. Using two groupings of competitive states, statistical evidence was found that exports from a state are affected adversely by the promotional expenditures of other states; however, another reasonable variable designed to capture this effect was statistically insignificant. Thus, definitive conclusions about the effects of export promotion expenditures are not possible. Nonetheless, one suggestion does emerge. In light of the large increases in expenditures and the increasing use of financial incentives to promote state exports, the competitive and efficiency aspects of export promotion expenditures and programs deserve additional scrutiny.[18] At this point, the lack of time-series data is the major obstacle.

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Money Demand and Inflation in Switzerland: An Application of the Pascal Lag Technique

IN 1973, the Swiss National Bank ceased pegging the Swiss franc to the U.S. dollar. In so doing, the Swiss monetary authorities gained control over the domestic money stock. This article describes the role of money demand estimates in the new monetary policy. It then assesses this foundation of policy by developing a statistical model for money demand tailored to the current exchange rate and monetary control regime.

SWISS MONETARY POLICY

Under the Bretton Woods system, Switzerland was one of many countries to experience the transmission of U.S. inflation to its economy. Because the Swiss National Bank pegged the exchange rate of the Swiss franc against the U.S. dollar, there was a close connection between U.S. and Swiss inflation. Arbitrage saw to it that changes in the dollar prices of internationally traded goods were matched by proportional changes in corresponding Swiss franc prices. Competition caused the prices of Swiss domestic goods to keep pace with the prices of internationally traded goods. Meanwhile, the public adjusted the Swiss money stock to the rising price level, in order to hold real money balances at the desired level.[1]

The Determination of Monetary Targets

The beginning of 1973 marked a change in the monetary regime. With the transition to flexible exchange rates, the Swiss monetary authorities

[1]This does not mean that inflation is not a monetary phenomenon. Under fixed exchange rates, inflation in a particular country is not caused by the money growth of that country, but by the combined money growth of all countries participating in this monetary arrangement. In such an environment, a small country is a price taker, with virtually no influence on the world price level. When the exogeneous price level rises, domestic residents restore their real balances by accumulating foreign exchange (dollars) through current account surpluses. These earnings are then converted to domestic currency (Swiss francs) by the central bank (the Swiss National Bank) which is ready to make any transaction at the given exchange rate.

Monetary Targets and Monetary Growth

At the end of 1974, the Swiss National Bank (SNB) announced the first monetary target.[1] Until 1978 M1 targets were used. These targets were translated into operational targets for the monetary base. To accomplish this, a dynamic model forecasting the multiplier (the ratio between M1 and the base) was developed.[2] The policy was implemented mainly through foreign exchange purchases and sales.

The actual course of the money stock did not always follow its announced path. The table at right shows the targeted and effective money growth rates up to 1986. The Swiss National Bank tried, mainly in the seventies, to dampen erratic movements of the exchange rate. In 1978, for example, the Swiss franc appreciated strongly against the dollar; as a result, Swiss exports of goods and services, approximately 40 percent of gross national income, declined. To prevent further appreciation of the Swiss franc, the monetary authority expanded the money supply far beyond the target.[3] The monetary target for 1978 was abandoned in September. There was no target for 1979, and since 1980 targets for the adjusted monetary base have been used.[4]

While exchange rate considerations led to marked deviations from the projected money path, these deviations were neutralized in the long run. On average, over the 11 years for which targets were announced, the annual money growth was only 0.14 percent higher than the targeted value.

Monetary Growth: Targeted and Effective

	Target Variable[1]	Target[2]	Effective[2]
1975	M_1	6	4.4
1976	M_1	6	7.7
1977	M_1	5	5.5
1978	M_1	5	16.2
1979	—	—	—
1980	M_0	4[3]	−0.6[3]
1981	M_0	4	−0.5
1982	M_0	3	2.6
1983	M_0	3	3.6
1984	M_0	3	2.5
1985	M_0	3	2.2
1986	M_0	2	2.0

This table is updated from Kohli and Rich (1986).

[1]M_1 covers currency outside the federal government and the commercial banks, as well as demand deposits of Swiss nonbanks with the postal giro system and the commercial banks. M_0 stands for the adjusted monetary base (deposits of private sector with the SNB and outstanding bank notes less the month-end bulge in SNB credit to the commercial banks).

[2]Average of monthly year-on-year rates of change.

[3]The target for 1980 was defined as the average percentage increase in M_0 over the level of November 1979. For each month of 1980, the percentage increase over the level of November 1979 was calculated. The monthly growth rates were in turn compounded in order to obtain annualized rates. The effective rate of −0.6 percent represents the average of the annualized growth rates.

[1]Kohli and Rich (1986) provide a survey of the Swiss experiment of monetary control. For a comparison of U.S. and Swiss experience with monetary targeting, see Rich (1987).

[2]See Büttler et al (1979) on the multiplier model.

[3]See Niehans (1984), chapters 11 and 13, for an in-depth treatment of the relation between the money supply and real exchange rate fluctuations.

[4]Rich and Béguelin (1985) give detailed information on both M1 and base targeting and reasons for the transition to the latter.

could determine domestic money growth and inflation independently.

Monetary targets played a central role in the implementation of the new policy (see shaded insert above). The Swiss National Bank relied strongly on money demand estimates in establishing those targets. An early econometric study of Swiss money demand was published by Schelbert in 1967. In later research, Vital (1978), Kohli (1985), and Kohli and Rich (1986) pooled data from the fixed and the flexible exchange rate period in their samples. According to these studies the deflated monetary aggregates (from the monetary base to M3) can be well explained by two variables: the interest rate and national income.

The long-run goal of Swiss monetary policy is price level stability. In order to achieve this goal, the nominal money stock has to increase by as much as the growth in the demand for real money balances. This is where the money demand estimates enter the policy-making process. Since interest rate changes are hardly predictable, they are not taken into consideration when formulating the monetary target. This leaves the income elasticity of money demand as the decisive coefficient. Multiplying the income elasticity by the expected growth of real income provides an estimate of the growth of the money supply consistent with a stable price level.

The statistical findings indicate that the income elasticities of the demand for base money and M1 are close to unity. This leads to the rule of thumb that price level stability can be achieved if money growth is equal to the growth of real income. The growth potential of the Swiss real income is estimated to be around 2 percent per year.[2] Accordingly, the Swiss monetary targets have been gradually lowered over time to 2 percent in 1986.

Monetary Regime and Money Demand Estimation

With the change to flexible exchange rates, the estimation of the money demand function must be reconsidered. Under the current regime of monetary control, the nominal money supply is exogenous. Consequently, price level movements must bring aggregate real money balances in line with the desired level. The Chow money demand specification, the one most widely used in Swiss money demand estimates, does not adequately capture this adjustment process.[3] This problem appears in empirical findings: Heri (1986) reports that the explanatory power of a Chow specification decreases substantially when the sample contains data only from the flexible-exchange-rate period.

The present article develops a model of price level adjustment to estimate Swiss money demand for the period from I/1973 to IV/1986. Since we are interested in accurate measurements of the income and interest rate elasticities, an estimation procedure is chosen that considers a broad range of dynamic adjustments of the price level.

ESTIMATING THE MONEY DEMAND FUNCTION FOR THE FLEXIBLE-EXCHANGE-RATE PERIOD

We start with a long-run demand for money function:

(1) $M_r^d = f(Z)$,

where M_r^d denotes real money balances demanded, and Z is a set of variables, usually including a measure of real income and one or more interest rates. Equilibrium requires that equation 2 holds:

(2) $M/P^* = M_r^d$.

The nominal money stock, M, is exogenous. Therefore, this equation determines the equilibrium price level P*. The actual price level, P, does not always equal P*. Laidler (1985) elaborates:

> When a flexible price economy is pushed off its long-run demand-for-money function, it moves back by way of the influence of price level changes on the stock of real balances. If the price level is perfectly flexible, such adjustment is instantaneous, and only a long-run aggregate demand-for-money function is observable. However, if prices move less than instantaneously, we would observe the economy moving slowly to equilibrium over time by way of price level changes influencing the quantity of real balances.[4]

To illustrate this point, consider the following experiment: We start with the price level in equilibrium (at P_0^*). Now, the quantity of money is increased. At the prevailing price level, real balances are above their equilibrium value, which induces people to increase their spending and investment. In an economy close to full employment, the increased demand will drive up prices.

In this process, existing contracts are renegotiated over time. Hence, the price level does not jump to the new equilibrium (P_1^*) immediately; instead, it adjusts gradually. Figure 1a shows two possible shapes of this adjustment process.[5] In its

[2]For an up-to-date study of the Swiss potential real income growth, see Büttler, Ettlin and Ruoss (1987).

[3]Chow (1966) introduced the following adjustment specification for money demand estimates:

$M_{r,t} - M_{r,t-1} = \beta(M_{r,t}^d - M_{r,t-1}) \quad 0<\beta\leq 1,$

where M_r denotes real money balances, and M_r^d is the long-run money demand. Laidler (1985), pp. 111–12, points out that this "real adjustment" version coincides with a price adjustment version based on the partial-adjustment hypothesis only if the money supply is invariant over time.

[4]Laidler (1985), p. 111.

[5]The notion that the real money stock can deviate from the desired money stock and that this discrepancy is only slowly diminished through price level changes has recently been called the "buffer stock concept" of money. Laidler (1987) gives a description of buffer stock money and the transmission mechanism.

Figure 1a
Adjustment Paths of the Price Level

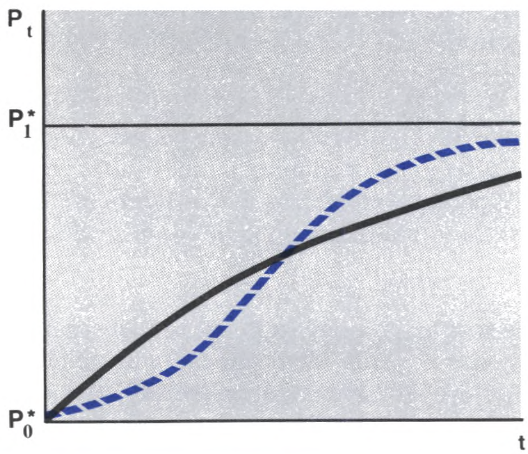
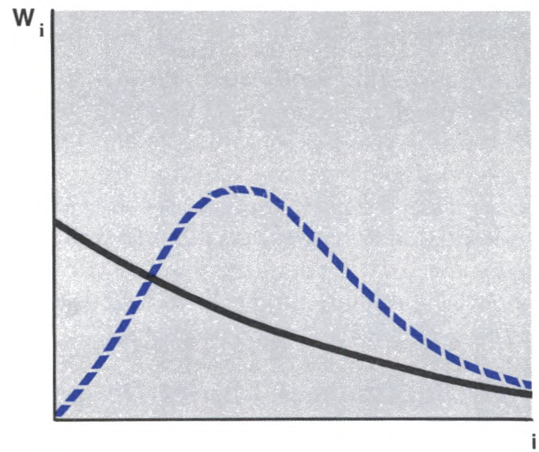


Figure 1b
Lag Weights for the Price Level Adjustment



general form, the adjustment process can be written as

$$(3)\quad P_t = \sum_{i=0}^{\infty} w_i P^*_{t-i},$$

$$\text{with} \quad \sum_{i=0}^{\infty} w_i = 1.$$

Figure 1b shows the pattern of lag weights (w_i) that correspond to the two adjustment paths in figure 1a.[6] The lag weights are also called the speed of adjustment since they measure the adjustment of the price level per unit of time. The Koyck lag, the simplest case, is denoted by the solid line. It can be derived from a partial-adjustment hypothesis which states that the gap between P_t and P_t^* is closed by a constant fraction (β) per unit of time. This implies that the adjustment speed of the price level is highest at the beginning and diminishes steadily thereafter. Because of its simplicity, this adjustment specification has been the most popular form of capturing the dynamic aspects of money demand.[7]

Laidler questions the application of the partial adjustment hypothesis to the behavior of the price level. He writes:

> [W]e would have to argue that it is possible to capture in one simple parameter β the entire transmission mechanism whereby the price level responds to discrepancies between the supply and demand for nominal money. This might be possible, though it seems implausible to say the least.[8]

Laidler concludes that if we are suspicious of the validity of the partial-adjustment hypothesis, then we must also be suspicious of all other parameters (for example, income and interest rate elasticities) estimated with a partial-adjustment specification.

Estimates for Switzerland suggest that the response of the price level to changes in the money stock resembles the pattern shown by the dashed line in figures 1a and 1b.[9] This adjustment is characterized by a slowly increasing adjustment speed in the initial stage of the process; it takes time for the price level movement to build momentum. To get accurate estimates of income and interest rate elasticities, it is therefore worthwhile to consider a

[6]Equations 2 and 3 ensure that a constant growth rate of money eventually leads to a rate of inflation equal to the rate of money growth.

[7]See Thornton (1985) for a concise overview of applications of the partial-adjustment hypothesis in money demand estimates.

[8]Laidler (1985), p. 111.

[9]See Wasserfallen (1985) and Zenger (1985).

wider range of possible lag patterns than just the Koyck specification.

The Pascal Lag Technique

The Pascal lag distribution is a flexible instrument for capturing the dynamic adjustment process discussed above. Solow (1960) suggested that the w_i in equation 3 can be represented by the Pascal distribution. Applied to the case at hand, this specification takes the form:

$$(4)\ P_t = (1-\lambda)^r \sum_{i=0}^{\infty} \binom{r+i-1}{i} \lambda^i P^*_{t-i} + \varepsilon_t,$$

where r is a positive integer, λ is a parameter to be estimated, and ε_t denotes an error term. The combination term in parentheses after the summation sign is a scalar value that depends on r and i. Kmenta (1986) presents an instructive graphical example of how the shape of the lag changes with different values of r.[10] In the simplest case (r = 1), the Pascal lag reduces to the Koyck lag. Thus, this technique captures a Koyck-type adjustment while opening the possibility of tracing a lag pattern similar to the dashed line in figure 1b.

The Pascal lag is estimated with a maximum likelihood procedure, that searches for the parameter values that minimize the residual sum of squares. It can be estimated in either its autoregressive form or in its distributed lag form.[11] In this study, the distributed lag form is chosen because a possible misspecification of the serial correlation properties of the residual process can lead to flawed parameter estimates in the autoregressive specification.[12] As Maddala and Rao suggest, the order of the Pascal Lag (r) can be chosen by selecting the specification that maximizes the adjusted R^2.

The lag technique used here implies an infinite adjustment process. Because of the finite sample size, this poses a problem. Two ways to deal with this issue shall be briefly described for the simplest case, the geometric lag.[13] Equation 4 can be written as

$$(4')\ P_t = (1-\lambda) \sum_{i=0}^{t-1} \lambda^i P^*_{t-i} + (1-\lambda) \sum_{i=t}^{\infty} \lambda^i P^*_{t-i} + \varepsilon_t.$$

The first part on the right-hand side contains exogenous variables as far back as the sample period runs. The second term contains values that go back to infinity. This second term, however, can be written as

$$(1-\lambda) \sum_{i=t}^{\infty} \lambda^i P^*_{t-i} = \lambda^t E(P_0).$$

Thus, the term $\lambda^t E(P_0)$ can be substituted for the infinite part of the equation. In exchange for avoiding the problem of dealing with an infinite series, however, we face a new problem: the expected value of P_t [$E(P_0)$ for t = 0] is not observable. This problem is approached in two ways. First, $E(P_0)$ is estimated by including an additional parameter.[14] Second, the actual value of P_0 is used in place of $E(P_0)$. The first procedure shall be called "the method of free parameters;" the latter shall be called "the method of determined parameters."

The Specification of the Model

The specification of the long-run money demand function is

$$(5)\ m_t - p^*_t = \alpha_0 + \alpha_1 y_t + \alpha_2 R_t \quad \alpha_1 > 0,\ \alpha_2 < 0.$$

The estimates are conducted with differenced data. Therefore, no estimate of the constant (α_0) is provided. Lower case letters denote logarithmic variables. The semi-logarithmic specification of money demand is the most widely used in Switzerland. All variables (except the income, y_t) are quarterly averages. The price level is represented by the consumer price index. The money stock variable is M1, and the income variable is the real gross domestic product. R_t is the return (in per-

[10] Kmenta (1986), p. 537.

[11] See Maddala (1977) for a comprehensive treatment of the Pascal lag. Maddala and Rao (1971) give a thorough description of the estimation methods for the Pascal lag model.

[12] See Maddala and Rao p. 84, and Harvey (1985), chapter 7.

[13] Following Maddala, and Maddala and Rao.

[14] With the increasing order of the Pascal lag an increasing number of expected initial values must be replaced by new parameters (see Maddala and Rao, p. 80). That is why a selection criterion ($\bar{R}^2$) is used that is adjusted for the degrees of freedom.

centage points) on three-month Euro-deposits in Swiss francs.[15]

Estimation Results

The first round of estimates is conducted by using the method of free parameters. The equilibrium price level in equation 4 is replaced by its determinants according to equation 5. The following equation is then estimated:

$$(6)\ \Delta p_t = (1-\lambda)^r \sum_{i=0}^{\infty} \binom{r+i-1}{i} \lambda^i (\Delta m_{t-i} - \alpha_1 \Delta y_{t-i} - \alpha_2 \Delta R_{t-i}) + \varepsilon_t.$$

Table 1 contains the $\bar{R}^2$s and the estimates of λ for orders of the Pascal lag ranging from one to four. The λ estimates, which range from 0.77 to 0.97, indicate that the empirical adjustment is rather slow; fast adjustment would imply a λ close to zero. The lag distribution implied by the estimates of λ are shown in chart 1. Since the maximum $\bar{R}^2$ is achieved with the $r=2$ specification, the estimates reject the Koyck lag ($r=1$) as the best specification of the adjustment process. Visible for the optimal case ($r=2$) is a small adjustment of the price level within the quarter of the disturbance. In contrast to the Koyck lag, w_i reaches its maximum value only six quarters after the disturbance and then slowly decreases. It takes approximately 10 quarters for the price level to adjust by 50 percent toward a new equilibrium value. This is much closer to the 12 quarters that both Wasserfallen and Zenger report than the 19 quarters implied by the Koyck estimate. Chart 2, the empirical counterpart to figure 1a, shows the adjustment paths of the price level implied by the Pascal lag estimates for $r=1$ and $r=2$. The chart assumes an increase in the equilibrium price level from one to two in period one. The two adjustment paths show a similar response of the price level only over the first year.

Table 1

$\bar{R}^2$ Statistics and λ Estimates for Pascal Lag Estimates of Different Order (r): I/1973–IV/1986

r	$\bar{R}^2$	λ
1	0.3834	0.9663
2	0.4469	0.8677
3	0.4443	0.8025
4	0.4433	0.7741

Table 2 contains the parameter estimates and various statistics for the $r=2$ case. The two α coefficients have the expected signs. The interest semi-elasticity is very close to the corresponding estimate reported in Kohli and Rich (1986). The income elasticity, however, is substantially smaller than in previous estimates and not significantly different from zero. As the appendix points out, however, using the method of free parameters implicitly involves the estimation of time trends, which can affect the reported results.

The method of determined parameters is used to generate an alternative set of estimates. The $\bar{R}^2$ criterion again leads to the choice of the $r=2$ case as the best dynamic specification; the results are presented in table 3. The income coefficient is 0.83; this time, it is significantly different from zero. The other estimated coefficients are very close to the estimates obtained from the first method.

The method of determined parameters depends heavily on the starting values of the sample period. The model is correctly specified only when the initial values of P_t are equal (or nearly equal) to the expected values for which they are substituted. If this condition is not met, the estimate suffers from misspecification.[16] This flaw is likely to produce a

[15]Data on the gross domestic product (GDP) are released quarterly. The consumer price index, published monthly, is a better measure of Swiss inflation than the GDP deflator. The nominal GDP, and hence the deflator, are subject to larger revisions than the deflated GDP. The R^2s of the estimates decrease substantially when the consumer price index is replaced by the GDP deflator. Although the estimated coefficients remain virtually unchanged when the GDP is deflated with the consumer price index, the R^2s of the estimates decrease. Therefore, the officially deflated series for the GDP is used in this study. The interest rate for Euro-deposits in Swiss francs is considered the best indicator for the return on money market instruments in Switzerland. Published domestic rates are applicable to small investors; large investors are able to get Euromarket rates (about half a percentage point more than the domestic rate) even if they deposit their funds with a domestic bank.

[16]This can be seen with the terminology used in the appendix: while the method of free parameters searches for γ values that minimize the residual sum of squares, the method of determined parameters imposes arbitrary γ values.

Chart 1
Pascal Lag Estimates of Lag Weights for the Price Level Adjustment

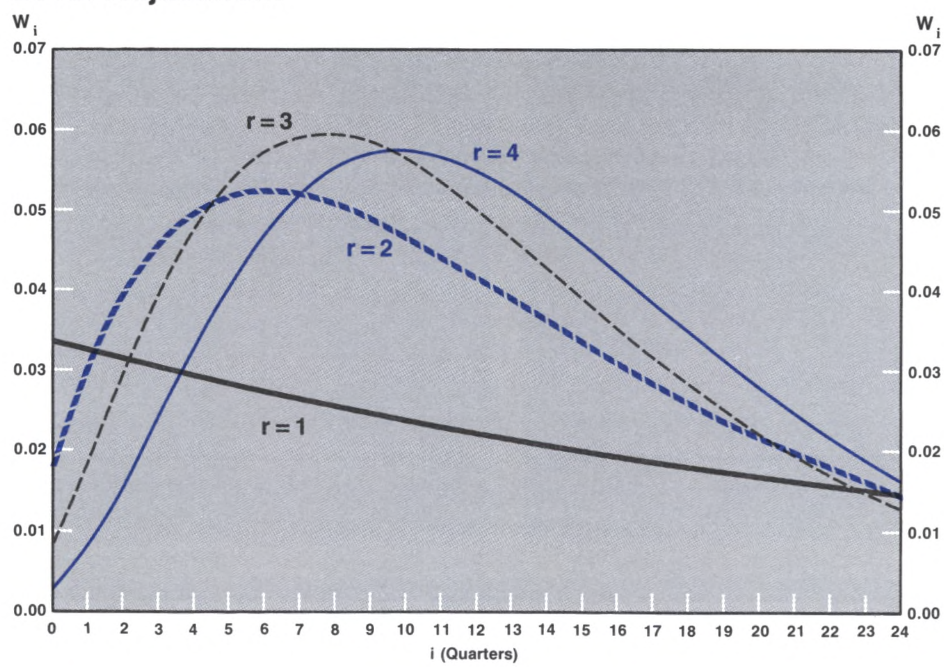


Chart 2
Pascal Lag Estimates of the Adjustment Path of the Price Level

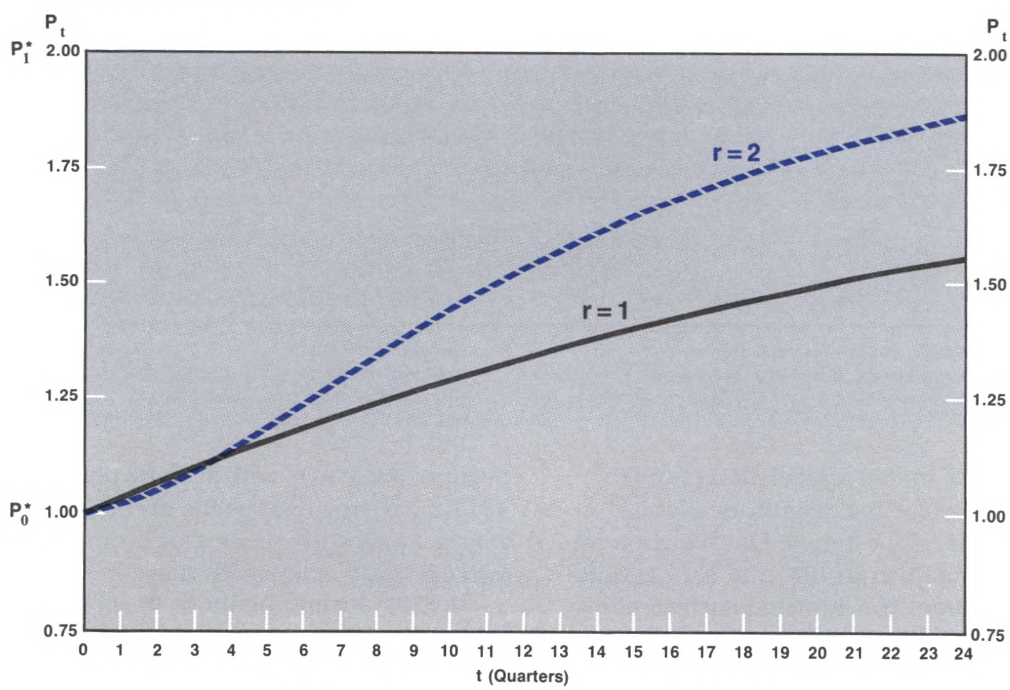


Table 2

Estimates of Pascal Lag (r = 2) Using the Method of Free Parameters: I/1973–IV/1986

λ	0.868*
	(53.17)
α_1	0.393
	(0.97)
α_2	−0.042*
	(5.45)
$\bar{R}^2$	0.45
DW	2.05
SSR	0.0023

Absolute values of t-statistic in parentheses.
* Indicates statistical significance at the 5 percent level.

Table 3

Estimates of Pascal Lag (r = 2) Using the Method of Determined Parameters: I/1973 – IV/1986

λ	0.830*
	(56.93)
α_1	0.830*
	(2.45)
α_2	−0.045*
	(7.50)
$\bar{R}^2$	0.41
DW	1.65
SSR	0.0029

Absolute values of t-statistic in parentheses.
* Indicates statistical significance at the 5 percent level.

Table 4

Estimates of Pascal Lag (r = 2) Using the Method of Determined Parameters

	Starting Point of Sample Period							
	73.2	73.3	73.4	74.1	74.2	74.3	74.4	75.1
λ	0.854*	0.628*	0.715*	0.758*	0.772*	0.803*	0.780*	0.892*
	(51.19)	(23.02)	(14.23)	(20.60)	(51.92)	(53.37)	(39.30)	(76.05)
α_1	0.628	0.586	1.198*	1.553*	0.482	0.799*	0.175	0.869*
	(1.64)	(1.54)	(2.75)	(4.05)	(1.44)	(2.36)	(0.44)	(2.21)
α_2	−0.043*	−0.023*	−0.023*	−0.031*	−0.044*	−0.050*	−0.022*	−0.056*
	(6.15)	(4.77)	(3.50)	(5.20)	(8.56)	(8.56)	(3.01)	(5.38)
$\bar{R}^2$	0.42	0.18	0.00	0.05	0.30	0.31	0.08	0.31
DW	1.79	0.66*	0.51*	0.65*	0.96*	1.08*	0.79*	1.75
SSR	0.0027	0.0088	0.0072	0.0050	0.0031	0.0027	0.0035	0.0014

Absolute values of t-statistic in parentheses.
* Indicates statistical significance at the 5 percent level.

poor fit and significant autocorrelation of the residuals. To get a feel for the magnitude of this problem, the model is reestimated with eight new starting points ranging from 1973.2 to 1975.1. Table 4 shows the outcome. The adjusted coefficient of determination ($\bar{R}^2$) varies widely with the starting value of the estimate. Six estimates show significant autocorrelation of the residuals. Only two estimates pass a Durbin-Watson test for misspecification; these two, with starting points 1973.2 and 1975.1, have the highest $\bar{R}^2$s in this series of estimates. Finally, the parameter estimates in these two cases are in line with those in tables 2 and 3.

Thus, while both methods of applying the Pascal lag to a relatively small data sample have their limitations, their estimates of the parameters of long-run money demand, as well as the dynamic adjustment process, are consistent.

SUMMARY AND CONCLUSIONS

This article deals with the estimation of money demand in Switzerland. During the period of monetary control since 1973, the public has adjusted real money balances to its desired level by means of price level changes. Thus, the estimation of money demand is tantamount to statistically tracking variations in the price level.

The Pascal lag technique frees the adjustment dynamics from the rigid corset of the partial adjustment process so frequently used in money demand studies. The statistical findings show that the partial adjustment process does not accurately describe how the price level adjusts to changes in its determinants. It takes approximately one and a half years for the adjustment speed of the price level to reach its maximum and about one more year before half of the necessary adjustment is completed.

Among the estimates that pass a test of misspecification, no income coefficient of money demand is statistically significantly different from one. Nevertheless, all point estimates are less than one. This result suggests that price level stability in Switzerland is more likely to be achieved with an M1 growth somewhat less than real income growth.

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Appendix
Implicit Time Trends in the Pascal Lag Estimation Using the Method of Free Parameters

This appendix demonstrates that using the method of free parameters to apply the Pascal lag to a finite sample size implies the estimation of time trends. The Pascal lag of order 2 serves as an example. The initial equation for this case is

$$\Delta p_t = (1-\lambda)^2 \sum_{i=0}^{\infty} (i+1)\,\lambda^i\,(\Delta m_{t-i} - \alpha_1\,\Delta y_{t-i} - \alpha_2\,\Delta R_{t-i}) + \varepsilon_t.$$

The infinite part of the equation is omitted by rewriting this equation as

$$\Delta p_t = (1-\lambda)^2 \sum_{i=0}^{t-2} (i+1)\,\lambda^i\,(\Delta m_{t-i} - \alpha_1\,\Delta y_{t-i} - \alpha_2\,\Delta R_{t-i}) - (t-1)\,\lambda^t\,E(\Delta p_0) + t\lambda^{t-1}\,E(\Delta p_1) + \varepsilon_t.$$

Using the method of free parameters means estimating this equation in the form:

$$\Delta p_t = (1-\lambda)^2 \sum_{i=0}^{t-2} (i+1)\,\lambda^i\,(\Delta m_{t-i} - \alpha_1\,\Delta y_{t-i} - \alpha_2\,\Delta R_{t-i}) - (t-1)\,\lambda^t\,\alpha_3 + t\lambda^{t-1}\,\alpha_4 + \varepsilon_t.$$

The estimation procedure is not designed to generate values of $\hat{\alpha}_3$ and $\hat{\alpha}_4$ that are equal to the corresponding $E(\Delta p)$ values. Instead, the maximum likelihood procedure will find values of these "free parameters" that minimize the sum of squared residuals:

$$\hat{\alpha}_3 = E(\Delta p_0) + \hat{\gamma}_1.$$

$$\hat{\alpha}_4 = E(\Delta p_1) + \hat{\gamma}_2.$$

Hence, implicitly, the method of free parameters respecifies the initial equation to

$$\Delta p_t = (1-\lambda)^2 \sum_{i=0}^{\infty} (i+1)\,\lambda^i\,(\Delta m_{t-i} - \alpha_1\,\Delta y_{t-i} - \alpha_2\,\Delta R_{t-i}) + \gamma_1\,(1-t)\,\lambda^t + \gamma_2\,t\lambda^{t-1} + \varepsilon_t.$$

The term thus added to the basic equation, $\gamma_1\,(1-t)\,\lambda^t + \gamma_2\,t\lambda^{t-1}$, is a time trend. The form of this time trend is limited: after a positive or negative value at the beginning of the sample, it eventually goes toward zero. The trend parameters, $\hat{\gamma}_1$ and $\hat{\gamma}_2$, however, cannot be estimated explicitly.

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The Effect of Monetary Policy on Short-Term Interest Rates

THE "liquidity effect" plays a central role in Keynesian theory of the transmission of monetary policy. It is based on the notion that the demand for money is negatively related to the nominal interest rate.[1] Other things the same, an exogenous increase in the money stock depresses nominal and real interest rates, stimulating aggregate demand.

Even though theorists acquiesce to the liquidity effect as a theoretical proposition, it is often challenged on efficacy grounds. It is argued that changes in the money stock do not leave all other things unchanged. Monetarists, such as Friedman (1968) assert that the liquidity effect is, at best, only temporary; the ultimate effect of more rapid money growth is higher inflation (or, more importantly, expectations of higher inflation) and, consequently, higher nominal interest rates. New classical economists argue that the real interest rate is determined by basic tastes and technology considerations, which are slow to change.[2] If increases in the money supply primarily affect the market's expectations of inflation, nominal interest rates will rise immediately.

Estimates of money demand equations, especially short-run equations, indicate that money demand is very interest inelastic, suggesting that there is a strong liquidity effect.[3] Most other empirical work, however, has estimated the total effect of changes in monetary policy on interest rates. A wide range of methodologies have produced diverse and sometimes conflicting results. This article is an attempt to consolidate the evidence on the responsiveness of interest rates to monetary changes. Various methods for estimating the relationship between interest rates and monetary impulses are reviewed and then applied to a common data set. Also, the analysis implicitly incorporates the possibility that the money stock is endogenous in the sense that the money multiplier depends on the interest rate.[4]

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[1]Until fairly recently, most forms of money were non-interest-bearing. Consequently, the opportunity cost of holding money was represented by the nominal interest rate. A large portion of M1 now is held in the form of interest-bearing NOW accounts. The opportunity cost of this component of M1 is the spread between market rates and the rate paid on these deposits.

[2]Recently, Niehans (1987) has argued convincingly that the description of the rational expectations school as "new classical economics" is a misnomer. He argues that its emphasis on continuous market-clearing constitutes a fundamental break from both classical and neoclassical economics.

[3]Many economists, for example Carr and Darby (1981), believe the liquidity effect implied by these equations to be implausibly large.

[4]The interest sensitivity of the multiplier is shown in models of the money supply process. For example in Thornton (1982), the behavioral equations are assumed to be linear; thus, although the multipliers are not functions of the interest rate per se, they are functions of the interest elasticities of these behavioral equations.

THE LIQUIDITY EFFECT

The liquidity effect is defined as the interest responsiveness of the demand for money in a simple model of liquidity preference where the money stock is assumed to be controlled directly and exogenously by the monetary authority.[5] For example, consider the following specification of the demand for nominal money

(1) $M^d = L(i, Py), L_i < 0, L_P, L_y > 0,$

where M, i, y and P denote the nominal money stock, the nominal interest rate, real income and the price level, respectively. If the money stock is taken as exogenous, $M^s = M$, the market equilibrium condition is

(2) $M = L(i, Py).$

Hence, the liquidity effect is defined as

(3) $di = (1/L_i)dM.$

While the theoretical relevance of the liquidity effect is acknowledged, analysts generally argue that it may be partially or totally offset quickly by other effects, both direct and indirect, of money stock changes. To see this, assume that the price level is positively related to the money stock and real output is negatively related to the interest rate. That is,

$P = P(M), P' > 0$

and

$y = y(i), y' < 0.$

Substituting the above expressions into equation 2, the effect of an exogenous change in the money stock on interest rates is

(4) $di = (1 - L_pP'y)dM/(L_i + L_yPy').$

This measure reflects not only the interest sensitivity of the demand for money, L_i, but the direct effect of money stock changes on the price level, $L_pP'y$, and the indirect effect of interest rates on income, L_yPy'.

The effect of an exogenous change in money on interest rates given by equation 4 is strictly smaller than the liquidity effect of equation 3 because of the income and price level effects. According to the Keynesian transmission mechanism, the lower nominal and, at this point real interest rate, stimulates aggregate demand and, hence, real income. The rise in real income increases the demand for money, causing interest rates to rise; this mitigates the initial liquidity effect. Equation 4 also incorporates the direct price level or the "Keynes effect". An increase in the nominal money stock causes the price level to rise, which in turn causes the real money stock to decline, resulting in an increase in interest rates.[6]

If money stock changes affect output or prices sufficiently rapidly, then the income and price level effects will offset, at least in part, the decline in interest rates associated with the liquidity effect. Moreover, it may be difficult to find a statistically significant *negative* relationship between changes in the money stock and changes in the interest rate if the data are averaged over a long period.[7] Indeed, if financial market participants anticipate the rise in income or the price level, these effects will be reflected in market interest rates immediately; thus the observed change in interest rates associated with a money stock change might be small even over short time periods.

The "Fisher Effect"

In addition to the income and price level effects incorporated in equation 4, there is also the possibility of the "Fisher effect." Fisher (1930) argued that, in the absence of differences in holding costs, the real, risk-adjusted return on assets should be the same regardless of the units in which the assets are expressed. Consequently, the return on physical assets should be the same as the return on credit contracts denominated in fixed units of nominal money. This implies that the interest rate on dollar-denominated contracts will reflect the

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[5]Because the liquidity effect usually is discussed in models where the money stock is assumed to be controlled by the monetary authority, it has become synonymous with the interest responsiveness of money demand. In a model where the money stock is endogenous, it may be more appropriate to think of the liquidity effect in terms of the impact of an exogenous change in monetary policy on interest rates. This would reflect not only the slope of the money demand function, but the slope of the money supply function as well.

[6]For notational convenience, equation 1 is written without imposing the usual assumption that L(.) is linear homogenous of degree one in P.

[7]This may be one reason why Peek (1982) and Wilcox (1983a), Makin (1983) and Hoffman and Schlagenhauf (1985) obtained different results using similar data and methodologies. All used the biannual Livingston survey data on inflation expectations; however, Makin, Hoffman and Schlagenhauf interpolated the data and estimated a quarterly model, while Peek and Wilcox used biannual data.

market's expectation of inflation over the duration of the contract. Hence, if an increase in money growth produces expectations of more rapid inflation, the nominal interest rate will rise.[8] The existence of a contemporaneous price expectation effect mitigates and possibly eliminates the liquidity effect on the nominal interest rates.[9]

The Effect of an Endogenous Money Supply

Until now, the money supply has been assumed to be controlled exogenously by the Federal Reserve. In the modern financial system, however, the total money stock is determined not only by the policy actions of the Federal Reserve, but by the portfolio decisions of depository institutions and the public. That is, the money supply is composed of both "inside" and "outside" money. Generally, there is no sense in which one can measure the effect of a change in the stock of endogenous, inside money on interest rates.[10] Instead, the effect of monetary changes on the interest rate is measured in terms of changes in outside money.

For example, assume that the money supply is endogenous in that the usual money multiplier is a function of the interest rate. That is, let the money supply be expressed as

$$(5) \quad M^s = m(i)H, \; m' > 0,$$

where H denotes the stock of "high-powered," outside money and m(i) denotes the usual money multiplier. Setting (5) equal to (1) results in the equilibrium condition

$$(6) \quad m(i)H = L(i, P(m(i)H)y(i)).$$

Consequently, the effect of an exogenous change in the stock of high-powered money on the interest rate is given by

$$(7) \; di = (1 - L_P yP')mdH/(L_i + L_y Py' + (L_P yP' - 1)m'H).$$

The responsiveness of interest rates measured by (7) is strictly smaller than that given by (4) for an identical exogenous change in the money supply, that is, $mdH = dM$.

The Role of Monetary Policy Objectives

There is an exception where it would be appropriate to measure the effect of monetary changes on interest rates in terms of the total money stock despite the presence of inside money. This occurs when the monetary authority is targeting the total money supply and when it is forecasting and quickly offsetting the effect of other factors on the supply of money.[11] For example, suppose that the Federal Reserve is targeting the total money supply but controls only H directly. If m were to rise, say due to a decrease in the public's desire to hold currency relative to checkable deposits, the Fed would attempt to offset the effect of the rise in the money stock by reducing H. If the Fed anticipated the rise in m and changed H by the appropriate amount immediately, there would be no change in the money supply or interest rates associated with the change in H. Estimates of the responsiveness of interest rates to changes in H would be biased downward. If, on the other hand, the Fed does not respond instantaneously, interest rates would be negatively associated with changes in H. In contrast, assume that there is an exogenous increase in the demand for money. If the Fed responds

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[8]The reader should note that there is a somewhat subtle difference between equating the liquidity effect to shifts in the stock of money and shifts in the growth rate of money. The problem here is that the Fisher effect, which relates the *level* of nominal interest rates to the *rate* of inflation, is fundamentally dynamic. The bridge that links these concepts can be found in the monetary growth models where, in long-run equilibrium, both the monetary growth rate and the nominal interest rate are constant. An exogenous increase in the growth rate of money produces a liquidity effect and potentially a Fisher effect. This difference is also reflected in empirical work. For example, compare the approach of Gibson (1970b) with that of Cagan and Gandolfi (1969).

[9]The outcome depends on a number of factors, including the homogeneity of the demand for real money with respect to the price level. If there is no money illusion, the nominal interest rate must rise point for point with the expected rate of inflation. Consequently, if the inflation consequences of an increase in the growth rate of the money stock are fully anticipated, the nominal rate must rise with the acceleration in money growth.

[10]See Patinkin (1965), pp. 297–301, for a good discussion of this point. Of course, this does not apply to exogenous shifts in the stock of inside money, such as a gold discovery under a gold standard.

[11]See Thornton (1984) for a discussion of this point in terms of the issue of debt monetization. Also, see Mishkin (1982) for a discussion of the effects of this form of money stock endogeneity or estimates of the market's response to changes in the money stock.

Also, Mishkin (1981) and Robinson (1988) use M2 to measure the responsiveness of interest rates to changes in the money supply. This is odd since changes in M2 are much more likely to be related to factors other than policy changes.

instantly to offset the effect of this increase on the money stock, interest rates will rise while the money remains unchanged and the stock of high-powered money is reduced. If the Fed does not respond instantaneously, both interest rates and the money stock will initially rise, then interest rates will continue to rise as the money stock falls. The point here is that whether the total money stock or the stock of high-powered money should be used depends on whether the Fed is trying to control the money stock and on how rapidly it is responding to other factors that influence money. This observation has implications for empirical work. If the Fed is attempting to control the total money stock and if the Fed moves reasonably quickly to offset the effect of other factors, measuring the responsiveness of interest rates in terms of the total money supply would be appropriate even if day-to-day or week-to-week shocks were not offset instantaneously.

To determine whether the estimated responsiveness of interest rates is sensitive to the monetary variable used, alternative measures of the monetary impulse are used. This is necessary because the Fed often relies on multiple objectives and is not explicit about them.[12] Of course, if m' is small, the choice of a monetary variable will be relatively unimportant.

Policy-Related Endogeneity

The endogeneity of the money stock discussed above is based upon the economic response of depository institutions and the public to changes in nominal interest rates. Another monetary-policy related view holds that the money supply is endogenous whenever the Fed is using short-term interest rates as an intermediate policy target. In this instance, the Fed merely adjusts the money stock to shifts in the demand for or the supply of money over which it has no control. In the case of exogenous shifts in the money supply function, the Fed neutralizes the effect of such shifts on nominal interest through appropriate open market operations.[13] As a result, both the nominal money stock and the interest rate are unchanged. In the case of shifts in the demand for money, the Fed uses open market operations to accommodate changes in the demand for money. The interest rate remains unchanged, but the money stock changes.

This type of endogeneity creates severe problems for isolating the responsiveness of interest rates to monetary changes because only the market equilibrium values of the interest rate are observed. Since the interest rate is unchanged, despite changes in the money stock, the responsiveness of interest rates to changes in the money stock appears to be nil.[14] If the Fed offsets only part of a demand shift, however, money stock and interest rate changes will be positively correlated. If only part of the exogenous supply shifts are offset, money and interest rates will be negatively correlated. Consequently, statistical analysis may show a positive, negative or no statistically significant relationship between interest rates and money growth, despite the fact that it is precisely because of the liquidity effect that compensatory open market operations are undertaken.

If the Fed reacts instantaneously to these shocks, evidence of the effect of changes in the money stock on interest rates can be obtained with precise knowledge of the Fed's interest rate target. Unfortunately, such information is generally unavailable.[15] Alternatively, a time interval short enough to isolate the response of the market

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[12]For example during most of the 1960s and the early 1970s, the policy directives of the Federal Open Market Committee to the Trading Desk were stated in terms such as "maintain the existing degree of credit restraint." Even when the Fed was targeting the monetary aggregates in the late 1970s and early 1980s, the policy directives often were stated in terms of multiple monetary aggregates and in loose terms, such as "run somewhat above the upper limit of the target range." Moreover, the money growth objectives frequently were conditional on movements of other variables such as the federal funds rate.

[13]The Fed's reaction to offset a supply-side shift is referred to as "defensive open market operations." Stabilizing the normal interest rate will be effective only if the change in the money stock does not give rise to inflationary or deflationary expectations. Proponents of this view would argue this will not happen because the Fed is merely accommodating shifts in the demand for money.

[14]In terms of a more formal model, let H^* be the stock of high-powered money required to hit some target interest rate i^*, i.e., $H^* = L(i^*,Py)/m(i^*)$. From this, $dH/dPy = LPy/m(i)$. The change in the equilibrium interest rate associated with a shift in the demand for money is given by $di/dPy = -[LPy/(L_i - m'H)] + [m(i)/(L_i - m'H)](dH/dPy)$. Substituting in for dH/dPy, yields $di/dPy = 0$.

[15]At times, the Fed's announced ranges for the federal funds rate were fairly narrow. It is difficult to use these ranges to model this relationship, however, because the relationship between the federal funds rate and the T-bill rate, which is usually used to estimate the responsiveness of interest rates to monetary changes, is itself not very stable.

to the Fed's actions could be used. In the absence of such detailed information or such a rich data set, it is important to measure the effect of monetary changes on interest rates during periods in which the Fed was attempting to exert greater control over the money supply.[16]

A REVIEW OF METHODOLOGIES

One method of estimating the responsiveness of interest rates to changes in the money stock, used by Cagan and Gandolfi (1969) and more recently by Melvin (1983) and Brown and Santoni (1983), is to regress the change in the nominal interest rate (Δi_t) on a distributed lag of unanticipated changes in the nominal money stock, ΔM^u. That is, the equation

$$(8)\ \Delta i_t = \alpha_0 + \sum_{i=0}^{K} \beta i\, \Delta M^u_{t-i} + \varepsilon_t$$

is estimated. The random error, ε, is assumed to be identically and independently distributed with a mean of zero and a constant variance, σ^2, that is, ε is iid$(0, \sigma^2)$. This equation is estimated with ordinary least squares (OLS).

A second approach used by Peek (1982), Wilcox (1983a), Mehra (1985), Hoffman and Schlagenhauf (1985) and Peek and Wilcox (1987) employs an IS-LM, aggregate demand/aggregate supply model.[17] In this model, commodity demand is a function of the real interest rate and money demand is a function of the nominal interest rate. While specific models differ, the following specification encompasses the essential features. The IS curve is given by

$$(9)\ y^*_t = a_0 - a_1 r_t + a_2 Z_t + v_{1t}$$

and the LM curve by

$$(10)\ (M_t - P_t) = b_0 + b_1 y^*_t - b_2 i_t + b_3 X_t + v_{2t}.$$

[Unless otherwise stated, all variables are in logarithms.] y^*_t denotes the deviation of real GNP from its "natural rate" (or full employment level), and P and r denote the price level and real interest rate, respectively. Z_t and X_t are vectors of variables that influence the demand for commodities and money, respectively, and v_{1t} and v_{2t} are stochastic disturbances such that v_{1t} is iid$(0, \sigma^2_1)$, v_{2t} is iid$(0, \sigma^2_2)$ and $E(v_{1t}\, v_{2t}) = 0$ for all t. The model is closed by the Phillips curve

$$(11)\ P_t = P^e_t + c y^*_t,$$

where the superscript "e" denotes the expectation based on information known before period t. Equations 9, 10 and 11 are solved for the real interest rate. The result is substituted into the Fisher equation,

$$(12)\ i_t = r_t + \pi^e_t,$$

where π denotes the rate of change in the price level, to yield a quasi-reduced form equation for the nominal interest rate

$$(13)\ i_t = A_0 + A_1 Z_t a_2 + A_2 X_t b_3 - A_3(M_t - P^e_t) + A_4 \pi^e_t + u_t.$$

The responsiveness of the interest rate to real money stock changes, $A_3 = [(c+b_1)a_1 + b_2]^{-1} > 0$, captures not only the "liquidity effect" (b_2), but also the net effect of all other factors that influence the equilibrium interest rate.

While equations 13 and 8 appear quite different, they are both reduced-form equations. The fundamental differences are that equation 13 is stated in *level* rather than first-difference form and that it explicitly includes factors, in addition to the money stock, that could affect nominal interest rates. The absence of these factors from equation 8 could be justified by arguing that it is a final-form equation, not simply a reduced-form equation. On the other hand, estimates of the response of interest rates based on equation 8 could be biased if variation in other factors that affect interest rates is not controlled for.[18]

Another difference is that equation 8 incorporates a distributed lag of unanticipated money, while equation 13 uses only the contemporaneous

[16]It should be noted that Mishkin's (1981, 1982) approach of using unanticipated money does not circumvent this problem. In this instance, unexpected changes in the money stock due to demand and supply shocks are different, so that the coefficient on unexpected money will be different depending on whether the shock emanates from the demand or supply side. Moreover, the effect of an unexpected change in the money supply will be different from the effect of a shock to the money supply.

[17]Actually, this approach was used earlier by Sargent (1969, 1972).

[18]Also, because equation 13 is a quasi-reduced form, the variables Z_t, X_t, P^e_t, M_t or π^e_t may be correlated with the error term. Consequently, OLS estimates of these equations may be inconsistent. Of course, the same would be true of equation 8 if the money stock is endogenous. This observation is the basis for Mehra's (1985) work.

level of actual money. The structure of equations 9–12 can be modified, however, to replace the monetary variable by its unexpected component; a distributed lag of unanticipated money also can be included by appealing to "price-stickiness" or Blinder and Fisher's (1981) inventory adjustment.[19]

A third methodology has roots in the rational expectations/efficient market literature.[20] Mishkin (1981, 1982) and, more recently, Hardouvelis (1986) and Robinson (1988) estimate the equation

$$(14)\ i_t - i_t^e = \alpha_0 + \alpha_1 I_t + \alpha_2(M_t - M_t^e) + \alpha_3(y_t - y_t^e) + \alpha_4(\pi_t - \pi_t^e) + \eta_t.$$

I_t denotes the set of information that market participants have available to them at the beginning of the period, while η_t denotes the error term. Mishkin characterizes equation 14 as the "rational expectations analog of the typical money demand relationship found in the literature."[21]

Mishkin derives equation 14 by using the efficient market/rational expectations model to argue that

$$i_t - i_t^e = (W_t - W_t^e)\beta + \omega_t,$$

where W_t is a vector of variables that reflect the "information relevant to the determination of short-term interest rates" and ω_t denotes the error term.[22] He then solves a monetary equilibrium condition for the interest rate in terms of all the other variables that enter the money demand function, that is, variables which appear as arguments in equation 1. He includes these variables in W_t, arguing that they are part of the relevant information set. Of course, any right-hand-side variable in equation 13 could be considered an element of W_t simply by broadening the theoretical framework. Consequently, equation 14 differs from the other specifications primarily in its explicit and complete reliance on the efficient markets/rational expectations paradigm.

Furthermore, equations 8, 13 and 14 are alternative representations for the nominal interest rate. Thus, they can be compared directly using standard nested and/or nonnested test procedures.

EMPIRICAL ESTIMATES OF THE LIQUIDITY EFFECT

The empirical estimates presented here cover the period from 1958.08 to 1987.06. Prior studies have generally used quarterly data when estimating equations 13 and 14 and monthly data when estimating equation 8. This study uses monthly observations for all specifications. The month period is short enough that the liquidity effect is less likely to be weakened by subsequent income, price level or inflation-expectations effects. On the other hand, many of the variables that might reasonably enter equations like 13 are unavailable on a monthly basis, so that the estimates are subject to a potential omitted-variables bias.

The variables used are

y = the real value of the industrial production index,

TBR = the three-month Treasury bill rate,

P = the CPI,

M = the M1 definition of the money stock,

MB = the Federal Reserve Bank of St. Louis adjusted monetary base,

and

NBR = the Federal Reserve Bank of St. Louis adjusted nonborrowed reserves.

Two measures of unanticipated changes in the money supply are used here. The first is the change in the growth rate of money. Cagan and Gandolfi use changes in the growth rate of money to proxy such changes, arguing that the market should respond only to unanticipated changes in the money stock.[23] Today, the unanticipated change

[19]For example, see Makin (1983) and Hoffman and Schlagenhauf (1985).

[20]Dwyer (1981) has an alternative rational expectations framework where, because the same factors affect both the expected inflation rate and the real interest rate, they give rise to a set of cross-equation restrictions that can be tested.

[21]Mishkin (1982), p. 66.

[22]Mishkin (1982), p. 64.

[23]Cagan and Gandolfi (1969) p. 279, state "It is hard to determine to what extent monetary changes at any particular time are anticipated, but presumably a steady growth rate will sooner or later come to be reflected in a corresponding rise in prices (allowing for the growth rate of real income). Consequently, changes in the monetary growth rate will tend to produce, every time they occur, a response in interest rates . . ." Gibson (1970a) uses a similar equation based on an analogous argument; however, Gibson (1970b) regresses first differences of the interest rate on first differences of the money stock.

in the growth rate of money typically would be obtained by subtracting expected money growth, estimated using some time-series method, from actual money growth. Nevertheless, because Cagan and Gandolfi's procedure has been utilized by all who have estimated equation 8, their measure of unanticipated money is used to see if the results are sensitive to the form of the unanticipated monetary variable.

Additionally, unanticipated money is measured by (ΔM-ΔM^e), where ΔM^e is a time-series representation of past ΔM. In this instance, the expected values of M, y and P are obtained by regressing each on a six-month distributed lag of itself and the other variables, including changes in the Treasury bill rate.[24]

This study uses three monetary policy variables: M1, the adjusted monetary base (MB), and nonborrowed reserves (NBR). The monetary base is used often as a measure of exogenous monetary policy. NBR is used because some would argue that it is a better measure of the exogenous monetary impulse than MB because depository institutions' borrowings from the Federal Reserve are related to the interest rate. Also, the Fed used a NBR-operating procedure to control the money stock from October 1979 to October 1982. Since the Fed was primarily targeting M1 growth during this period, however, unanticipated M1 growth may be a better measure of the exogenous monetary impulse during this period.

Alternative measures of the monetary impulse are used to see whether estimates of the responsiveness of interest rates to monetary impulses are dependent on the variable used.

Initially, the equation

$$(15)\ \Delta TBR_t = \alpha_0 + \sum_{i=1}^{6} \alpha_i \Delta TBR_{t-i} + \beta MV_t^u + \mu PV_t^u + \delta y V_t^u + \varepsilon_t$$

is estimated. The unanticipated monetary variable, MV^u, is alternately proxied by $\Delta\dot{M}1$, $\Delta\dot{M}B$, $\Delta N\dot{B}R$, ($\Delta M1$-$\Delta M1^e$), ($\Delta MB - \Delta MB^e$) and ($\Delta NBR - \Delta NBR^e$).[25] The unanticipated price (PV^u) and income (yV^u) variables are alternatively measured by $\Delta\dot{P}$ and $\Delta\dot{y}$ or ($\Delta P - \Delta P^e$) and ($\Delta y - \Delta y^e$).[26] This specification, and others which follow, include a finite distributed lag of the dependent variable to capture any effect of past information.[27]

OLS estimates of equation 15 for the period 1959.08–1987.06 and two subperiods, 1959.08–1973.09 and 1973.10–1987.06, are presented in tables 1–3. The split was made at 1973.09 because (1) it marks the well-known break in the demand for money, (2) it roughly coincides with the demise of the Bretton Woods agreement and (3) it also roughly coincides with the beginning of an era in which the Federal Reserve claimed to pay increasing attention to the growth rate of the monetary aggregates.[28] The equation is estimated with and without PV^u and yV^u to determine how sensitive the results are to these variables.

The results indicate considerable variability in the statistical significance of the effect of the monetary variables on interest rates, both across time and across monetary variables. During the entire period, there is a small but statistically significant negative effect for three of the unanticipated monetary variables. The largest statistically significant negative effect is obtained when $\Delta\dot{M}1$ is used, but there is a statistically significant negative response of interest rates when the unanticipated growth of nonborrowed reserves is used, whether it is measured by $\Delta N\dot{B}R$ or ($\Delta NBR - \Delta NBR^e$).

The results in tables 2 and 3 indicate that the responsiveness of interest rates to monetary impulses is sensitive to the sample period. When pre-1974 data are used (table 2) the effect is statistically significant only when the unanticipated change in the growth rate of nonborrowed re-

[24]This is similar to the multivariate time-series approach of Mishkin (1981) except that a distributed lag of the ΔTBR is included in all regressions. It is important to include all relevant variables that affect interest rates. Wickens (1982) has argued that if they are not included, the expectations cannot be efficient.

Also, there was some experimentation with alternative lag lengths. The lags used here appeared to work well and produced white noise residuals.

[25]When ($\Delta M - \Delta M^e$) is used, ΔM denotes the annualized first difference of the log of the variable. $\Delta\dot{M}$, however, is the first difference of the annualized growth rate of the variable. The same is true for all other variables.

[26]The unanticipated monetary, price and income variables are matched in the regressions. That is, if $\Delta\dot{M}1$ is used as the monetary variable, then $\Delta\dot{P}$ and $\Delta\dot{y}$ are used as the corresponding unanticipated price and income variables.

[27]The coefficients on the lagged dependent variable are not reported. In nearly every instance, they were jointly significant at the 5 percent level.

[28]Hafer and Hein (1982) date the break in money demand at 1973.04, while Lin and Oh (1984) date it at 1972.02. The United States formally broke from the Bretton Woods accord in late 1971.

The Federal Reserve Open Market Committee stated a desire to place increased emphasis on the growth of certain monetary aggregates at its January 15, 1970 meeting; Congress passed Resolution 133 requiring the Board of Governors to set long-run ranges for the aggregates on March 24, 1975.

Table 1

Estimates of Equation 15: 1959.08 – 1987.06

MV^u	Constant	MV^u	yV^u [1]	PV^u [1]	$\bar{R}^2$	SEE
$\Delta\dot{M}1$	.008	−.015*	.003	.014*	.254	.5089
	(0.28)	(3.68)	(1.25)	(1.71)		
	.008	−.016*	—	—	.250	.5103
	(0.30)	(3.79)				
$\Delta\dot{M}B$	.008	−.000	.003	.016*	.223	.5194
	(0.29)	(0.05)	(1.37)	(1.85)		
	.009	−.000	—	—	.217	.5214
	(0.30)	(0.06)				
$\Delta N\dot{B}R$	.008	−.005*	.003	.011	.251	.5099
	(0.28)	(3.49)	(1.31)	(1.31)		
	.008	−.004*	—	—	.249	.5107
	(0.29)	(3.74)				
$(\Delta M1 - \Delta M1^e)$	.009	−.007	.008*	.029*	.242	.5129
	(0.31)	(1.23)	(2.88)	(2.46)		
	.009	−.006	—	—	.219	.5206
	(0.31)	(1.04)				
$(\Delta MB - \Delta MB^e)$	.009	.014	.009*	.040*	.260	.5069
	(0.31)	(1.51)	(3.16)	(3.36)		
	.009	.017	—	—	.225	.5186
	(0.31)	(1.89)				
$(\Delta NBR - \Delta NBR^e)$	.009	−.009*	.008*	.033*	.320	.4860
	(0.33)	(5.41)	(2.94)	(3.00)		
	.009	−.010*	—	—	.293	.4954
	(0.32)	(5.94)				

[1]Since the coefficients on these variables are hypothesized to be positive, the significance tests are one-tailed.

* Indicates statistical significance at the 5 percent level.

serves is measured by $(\Delta NBR - \Delta NBR^e)$ and when PV^u and yV^u are omitted. Even in this case, however, the strength of the effect is small.

In contrast, there is a statistically significant negative effect during the latter period (table 3) when $\Delta\dot{M}1$ or NBR, in either form, is the monetary variable. These results are interesting because they suggest that the response of interest rates is stronger during the latter period, when the Fed claims to have paid more attention to monetary aggregates and when Melvin (1983) reports that the effect vanishes. Finally, the coefficient for unanticipated base growth measured by $(\Delta MB - \Delta MB^e)$, is significantly positive during this period.

Both quantitatively and qualitatively, the results are similar whether the unanticipated price or income variables are included. Accounting for the possible effect of unanticipated inflation or income growth does not appear to be important in measuring the effect of unanticipated monetary growth on interest rates.[29] The effects of unanticipated inflation and income growth are highly significant for the entire period, but they are much less so during the individual subperiods.[30]

[29]This result is not too surprising in the case where the unanticipated variables are measured by the difference between actual and expected. It is usually assumed, either explicitly or implicitly, that in the case where the expectation-generating equations are jointly estimated with the "structural" equation, the unanticipated components are mutually orthogonal. (Estimates indicate that this condition is reasonably satisfied for the specifications used here). When these variables are measured in this way, the regressors of equation 15 are nearly mutually orthogonal. Consequently, the parameter estimates of one are not likely to be affected by the absence of the others.

[30]This could be a manifestation of the heteroskedasticity in the data. In general, heteroskedasticity may cause the reported standard errors of the parameters of OLS to be biased, and they can be either too large or too small.

Table 2

Estimates of Equation 15: 1959.08 – 1973.09

MV^u	Constant	MV^u	yV^u [1]	PV^u [1]	$\bar{R}^2$	SEE
$\Delta\dot{M}1$	.017	.001	.001	.007	.160	.2544
	(0.86)	(0.32)	(0.56)	(1.28)		
	.017	.001	—	—	.162	.2542
	(0.88)	(0.16)				
$\Delta\dot{M}B$	.017	.000	.001	.007	.160	.2545
	(0.87)	(0.10)	(0.54)	(1.21)		
	.017	−.001	—	—	.162	.2541
	(0.88)	(0.30)				
$\Delta N\dot{B}R$	.017	−.000	.001	.007	.160	.2544
	(0.87)	(0.21)	(0.54)	(1.19)		
	.017	−.000	—	—	.162	.2541
	(0.88)	(0.42)				
$(\Delta M1 - \Delta M1^e)$	.017	.006	.001	.017	.172	.2527
	(0.89)	(1.10)	(0.37)	(1.66)		
	.017	.006	—	—	.168	.2533
	(0.88)	(1.11)				
$(\Delta MB - \Delta MB^e)$	.017	.001	.002	.013	.161	.2543
	(0.88)	(0.20)	(0.82)	(1.28)		
	.017	.002	—	—	.162	.2542
	(0.88)	(0.25)				
$(\Delta NBR - \Delta NBR^e)$	.017	−.003	.002	.022*	.198	.2487
	(0.90)	(1.82)	(1.07)	(2.20)		
	.017	−.004*	—	—	.182	.2511
	(0.89)	(2.02)				

[1]Since the coefficients on these variables are hypothesized to be positive, the significance tests are one-tailed.

* Indicates statistical significance at the 5 percent level.

Because the results could be specific to the form of equation 15, the equation

$$(16)\ \Delta TBR_t = \alpha_0 + \sum_{i=1}^{6} \alpha_i \Delta TBR_{t-i} + \sum_{i=0}^{36} \beta_i MV^u_{t-i} + \varepsilon_t,$$

was estimated using the same data for the same periods.[31] These results, reported in tables 4–6, are strikingly different from those in tables 1–3. For the entire period (table 4) there is no statistically significant, negative response of interest rates, even initially, when $\Delta\dot{M}1$ or $\Delta\dot{M}B$ is used. Moreover, the sum of the coefficients is significantly positive for both monetary variables. These results are consistent with those reported by Cagan and Gandolfi (1969), Brown and Santoni (1983) and Melvin (1983). When $\Delta N\dot{B}R$ is used, however, there is a significant initial negative response of interest rates for the entire period, and the sum of the coefficients is negative and significant.

The results using the unanticipated monetary variable measured by $(\Delta MV - \Delta MV^e)$ are considerably different from those using $\Delta\dot{M}V$.[32] For both M1 and MB, few coefficients are significant and most of these are positive. Also, while the sums of the coefficients are positive, they are not statistically significant. When NBR is used, the initial coefficient is negative and significant, but the sum of the coefficients is positive and not significant.

Most of the results for the pre-1974 period (table 5) are qualitatively the same as those for the entire period. One exception is for $(\Delta NBR - \Delta NBR^e)$, when the initial coefficient is negative but not significant

[31]Cagan and Gandolfi (1969) used 38 lags, Melvin (1983) used 36 and Brown and Santoni (1983) used 24. Because of the long lags involved, it was necessary to delete the first three years from the entire estimation period and from the first subperiod when $(\Delta MV - \Delta MV^e)$ is used as the monetary variable.

[32]OLS estimates of the standard errors of the coefficients are biased downward when unanticipated monetary variables are measured by $(\Delta MV - \Delta MV^e)$. Consequently, the reported t-ratios overstate the significance of the effect of unanticipated monetary impulses. See Pagan (1984) p. 234.

Table 3

Estimates of Equation 15: 1973.10 – 1987.06

MV^u	Constant	MV^u	yV^{u} [1]	PV^{u} [1]	$\bar{R}^2$	SEE
$\Delta\dot{M}1$	−.015	−.022*	.006	.027	.282	.6708
	(0.30)	(3.44)	(1.17)	(1.65)		
	−.016	−.022*	—	—	.274	.6745
	(0.30)	(3.45)				
$\Delta\dot{M}B$	−.013	−.002	.006	.028	.227	.6958
	(0.25)	(0.16)	(1.21)	(1.62)		
	−.014	−.000	—	—	.219	.6996
	(0.26)	(0.03)				
$\Delta N\dot{B}R$	−.014	−.006*	.005	.020	.269	.6766
	(0.26)	(2.99)	(0.91)	(1.22)		
	−.014	−.007*	—	—	.269	.6767
	(0.27)	(3.29)				
$(\Delta M1 - \Delta M1^e)$	−.014	−.013	.011*	.044*	.244	.6882
	(0.26)	(1.31)	(1.78)	(1.99)		
	−.014	−.010	—	—	.224	.6973
	(0.26)	(1.01)				
$(\Delta MB - \Delta MB^e)$	−.014	.030	.012*	.044*	.261	.6805
	(0.26)	(1.68)	(1.92)	(1.97)		
	−.014	.037*	—	—	.240	.6903
	(0.26)	(2.07)				
$(\Delta NBR - \Delta NBR^e)$	−.014	−.010*	.009	.045*	.314	.6556
	(0.27)	(3.53)	(1.50)	(2.16)		
	.014	−.012*	—	—	.296	.6641
	(0.27)	(4.15)				

[1]Since the coefficients on these variables are hypothesized to be positive, the significance tests are one-tailed.

* Indicates statistical significance at the 5 percent level.

and the sum of the coefficients is positive and significant.

The results for the post-1973 period (table 6) are different when NBR is used. The initial negative response of interest rates is larger during the post-1973 period and is statistically significant regardless of how unanticipated nonborrowed reserves are measured. The sums of the coefficients, however, are not significantly different from zero. Thus, while the magnitude of the negative effect is larger during this period, it is not permanent. The results for the M1 and MB measures are similar to those of the entire period.

Tests of Alternative Specifications

Tables 1–6 show that the results are sensitive to the specification of the monetary variable and to the sample period. Consequently, it is important to test which monetary variable, if any, best explains changes in the interest rate. To this end, the specifications with alternative monetary variables are tested against one another using the Davidson and MacKinnon (1981) J-test. In order for the test to favor specification A over specification B conclusively, the information in B must not be significant when specification A is the null hypothesis and the information in specification A must be significant when B is the null.

Table 7 presents the test results which, though largely inconclusive, favor M1 and NBR when unexpected money is specified in $\Delta\dot{M}V$ form. This is due solely to the post-1973 period, however. When the monetary variables are specified in $(\Delta MV - \Delta MV^e)$ form, the results tend to favor NBR.[33]

[33]Although not reported here, the results of the J-test applied to the specification given by equation 16 were also inconclusive.

Table 4

Estimates of Equation 16: 1962.08 – 1987.06

Lag	$\Delta\dot{M}1$	$\Delta M1 - \Delta M1^e$	$\Delta\dot{M}B$	$\Delta MB - \Delta MB^e$	$\Delta\dot{NBR}$	$\Delta NBR - \Delta NBR^e$
Constant	−0.033	−0.006	−.028	−.009	.033	.027
	(1.09)	(0.19)	(0.85)	(0.28)	(1.05)	(0.81)
0	−0.003	−0.005	0.021*	0.019	−0.010*	−0.011*
	(0.47)	(0.80)	(2.01)	(1.65)	(5.73)	(5.56)
1	0.037*	0.039*	0.052*	0.033*	−0.009*	−0.002
	(5.08)	(6.24)	(3.48)	(2.87)	(4.28)	(0.80)
2	0.033*	0.003	0.059*	0.009	−0.006*	0.003
	(3.66)	(0.43)	(3.19)	(0.75)	(2.47)	(1.57)
3	0.042*	0.005	0.058*	0.000	−0.008*	0.001
	(4.32)	(0.75)	(2.77)	(0.01)	(2.88)	(0.26)
4	0.030*	−0.002	0.039	−0.012	−0.007*	0.001
	(2.81)	(0.25)	(1.77)	(1.03)	(2.48)	(0.67)
5	0.033*	0.001	0.051*	0.026*	−0.011*	−0.003
	(3.01)	(0.08)	(2.26)	(2.20)	(3.29)	(1.22)
6	0.034*	0.016*	0.051*	0.021	−0.011*	−0.000
	(3.04)	(2.25)	(2.33)	(1.81)	(2.97)	(0.09)
7	0.032*	0.010	0.044*	−0.003	−0.011*	−0.001
	(2.96)	(1.38)	(2.07)	(0.29)	(2.98)	(0.47)
8	0.033*	0.009	0.031	−0.002	−0.011*	0.003
	(2.90)	(1.24)	(1.43)	(0.21)	(2.69)	(1.54)
9	0.033*	0.007	0.036	0.010	−0.010*	0.001
	(2.93)	(1.07)	(1.68)	(0.81)	(2.38)	(0.35)
10	0.036*	0.004	0.047*	0.02	−0.011*	−0.001
	(3.06)	(0.51)	(2.19)	(1.31)	(2.63)	(0.33)
11	0.046*	0.012	0.047*	0.007	−0.011*	−0.001
	(3.83)	(1.72)	(2.22)	(0.58)	(2.58)	(0.39)
12	0.042*	−0.002	0.055*	0.014	−0.007	0.005*
	(3.37)	(0.32)	(2.61)	(1.16)	(1.64)	(2.31)
13	0.023	−0.020*	0.040	0.002	−0.009*	0.000
	(1.83)	(2.92)	(1.90)	(0.14)	(2.02)	(0.14)
14	0.027*	0.000	0.054*	0.023*	−0.010*	−0.002
	(2.18)	(0.01)	(2.54)	(1.98)	(2.06)	(0.98)
15	0.032*	0.009	0.045*	0.007	−0.009	0.001
	(2.60)	(1.23)	(2.13)	(0.60)	(1.90)	(0.36)
16	0.021	−0.014	0.049*	0.008	−0.009	−0.002
	(1.64)	(1.97)	(2.31)	(0.69)	(1.92)	(0.86)
17	0.028*	0.009	0.058*	0.003	−0.010*	−0.001
	(2.27)	(1.18)	(2.76)	(0.28)	(2.03)	(0.68)
18	0.039*	0.004	0.064*	0.007	−0.011*	−0.002
	(3.11)	(0.57)	(3.07)	(0.60)	(2.37)	(0.84)
19	0.045*	−0.003	0.072*	0.009	−0.010*	−0.000
	(3.55)	(0.44)	(3.43)	(0.78)	(2.07)	(0.06)
20	0.037*	−0.008	0.065*	−0.003	−0.008	0.001
	(2.86)	(1.18)	(3.04)	(0.28)	(1.79)	(0.48)
21	0.032*	−0.012	0.059*	−0.002	−0.009	−0.000
	(2.53)	(1.74)	(2.76)	(0.14)	(1.93)	(0.15)
22	0.040*	0.002	0.066*	0.011	−0.010*	−0.002
	(3.13)	(0.23)	(3.09)	(1.03)	(2.18)	(0.86)
23	0.041*	0.004	0.060*	0.004	−0.009*	−0.000
	(3.18)	(0.57)	(2.77)	(0.36)	(2.02)	(0.11)
24	0.031*	−0.006	0.053*	0.008	−0.011*	−0.001
	(2.39)	(0.86)	(2.48)	(0.69)	(2.33)	(0.40)
25	0.027*	−0.001	0.053*	0.012	−0.007	0.004*
	(2.12)	(0.09)	(2.47)	(1.04)	(1.50)	(2.05)
26	0.026*	−0.006	0.048*	−0.006	−0.008	−0.000
	(2.08)	(0.80)	(2.23)	(0.49)	(1.74)	(0.15)
27	0.023	−0.008	0.034	−0.017	−0.009*	−0.002
	(1.89)	(1.08)	(1.61)	(1.53)	(2.17)	(0.72)
28	0.023	−0.001	0.036	0.001	−0.009*	−0.000
	(1.92)	(0.19)	(1.71)	(0.12)	(2.15)	(0.09)
29	0.024*	−0.002	0.041*	0.004	−0.009*	−0.000
	(2.10)	(0.33)	(2.00)	(0.37)	(2.29)	(0.16)
30	0.025*	−0.006	0.031	−0.012	−0.006	0.003
	(2.36)	(0.88)	(1.57)	(1.08)	(1.72)	(1.48)
31	0.022*	−0.005	0.034	0.005	−0.006	0.001
	(2.16)	(0.65)	(1.76)	(0.50)	(1.57)	(0.57)
32	0.024*	0.004	0.020	−0.006	−0.006	−0.000
	(2.40)	(0.53)	(1.13)	(0.51)	(1.83)	(0.02)
33	0.014	−0.004	0.022	−0.005	−0.005	−0.000
	(1.60)	(0.53)	(1.30)	(0.46)	(1.69)	(0.21)
34	0.021*	0.007	0.017	0.000	−0.001	0.004
	(2.62)	(0.99)	(1.12)	(0.02)	(0.49)	(1.88)
35	0.009	−0.005	0.019	0.004	0.002	0.003
	(1.30)	(0.73)	(1.54)	(0.37)	(0.62)	(1.35)
36	0.015*	0.010	0.013	−0.013	0.000	−0.000
	(2.59)	(1.48)	(1.37)	(1.21)	(0.25)	(0.17)
Sum of Lags	1.075*	.043	1.645*	.181	−0.304*	.001
	(3.76)	(0.94)	(3.30)	(1.89)	(2.77)	(0.09)
F[1]	2.82*	2.39*	1.22	0.99	1.65*	1.65*
$\bar{R}^2$	.37	.34	.24	.22	.28	.28
SEE	.4912	.5025	.5374	.5453	.5237	.5237

*Indicates statistical significance at the 5 percent level.

[1]F-statistic for the joint significance of the monetary variables.

Table 5

Estimates of Equation 16: 1962.08 – 1973.09

Lag	$\Delta\dot{M}1$	$\Delta M1-\Delta M1^e$	$\Delta\dot{M}B$	$\Delta MB-\Delta MB^e$	$\Delta N\dot{B}R$	$\Delta NBR-\Delta NBR^e$
Constant	–.024	.010	–.006	.010	.032	.041
	(1.03)	(0.47)	(0.23)	(0.43)	(1.48)	(1.93)
0	0.011	0.012	–0.007	–0.011	–0.004*	–0.003
	(1.72)	(1.74)	(0.84)	(1.23)	(2.33)	(1.46)
1	0.003	–0.001	–0.007	0.003	–0.008*	–0.001
	(0.38)	(0.15)	(0.58)	(0.37)	(2.70)	(0.57)
2	0.004	–0.002	–0.005	0.001	–0.009*	–0.000
	(0.39)	(0.36)	(0.38)	(0.08)	(2.37)	(0.02)
3	0.004	–0.006	–0.025	–0.022*	–0.011*	–0.002
	(0.43)	(0.81)	(1.66)	(2.38)	(2.60)	(0.98)
4	0.009	0.002	–0.009	0.012	–0.010*	0.002
	(0.81)	0.23	(0.57)	(1.26)	(2.10)	(0.99)
5	0.009	–0.004	0.003	0.012	–0.012*	–0.000
	(0.79)	(0.58)	(0.19)	(1.27)	(2.42)	(0.12)
6	0.016	0.012	0.012	0.010	–0.012*	0.002
	(1.50)	(1.67)	(0.71)	(1.10)	(2.27)	(1.11)
7	0.026*	0.019*	0.021	0.015	–0.013*	0.002
	(2.35)	(2.70)	(1.23)	(1.69)	(2.48)	(1.15)
8	0.031*	0.007	0.022	0.006	–0.012*	0.005*
	(2.62)	(1.01)	(1.29)	(0.67)	(2.13)	(2.39)
9	0.036*	0.007	0.019	0.004	–0.011	0.004
	(2.92)	(0.88)	(1.14)	(0.43)	(1.95)	(1.86)
10	0.048*	0.012	0.025	0.014	–0.013*	–0.000
	(3.78)	(1.64)	(1.49)	(1.56)	(2.21)	(0.04)
11	0.053*	0.006	0.017	0.001	–0.015*	–0.000
	(4.12)	(0.74)	(1.03)	(0.12)	(2.58)	(0.16)
12	0.041*	–0.008	0.023	0.003	–0.013*	0.004*
	(3.12)	(1.08)	(1.40)	(0.36)	(2.15)	(2.15)
13	0.035*	–0.002	0.009	–0.013	–0.011	0.004*
	(2.68)	(0.30)	(0.53)	(1.31)	(1.80)	(2.15)
14	0.023	–0.006	0.012	0.006	–0.010	0.003
	(1.77)	(0.72)	(0.72)	(0.59)	(1.70)	(1.21)
15	0.025	0.002	0.012	0.010	–0.008	0.003
	(1.93)	(0.23)	(0.70)	(1.10)	(1.51)	(1.57)
16	0.018	–0.009	0.010	–0.003	–0.011*	–0.000
	(1.38)	(1.27)	(0.56)	(0.29)	(2.14)	(0.12)
17	0.030*	0.005	0.021	0.010	–0.011*	0.003
	(2.21)	(0.68)	(1.24)	(1.12)	(2.24)	(1.29)
18	0.045*	0.018*	0.016	0.003	–0.010*	0.006*
	(3.39)	(2.57)	(0.92)	(0.32)	(1.96)	(2.76)
19	0.046*	0.001	0.021	0.014	–0.007	0.004*
	(3.41)	(0.12)	(1.21)	(1.56)	(1.47)	(2.02)
20	0.038*	–0.008	0.007	–0.009	–0.010*	–0.002
	(2.83)	(1.15)	(0.40)	(1.15)	(2.05)	(0.86)
21	0.034*	–0.004	0.017	0.011	–0.011*	0.001
	(2.57)	(0.58)	(1.00)	(1.39)	(2.15)	(0.40)
22	0.038*	0.005	0.027	0.011	–0.008	0.005*
	(2.94)	(0.65)	(1.62)	(1.35)	(1.61)	(2.48)
23	0.041*	–0.003	0.040*	0.011	–0.005	0.006*
	(3.15)	(0.40)	(2.45)	(1.29)	(0.93)	(2.88)
24	0.040*	–0.007	0.029	–0.011	–0.007	–0.002
	(3.09)	(0.91)	(1.72)	(1.30)	(1.34)	(1.06)
25	0.043*	0.004	0.025	0.002	–0.005	0.002
	(3.40)	(0.60)	(1.56)	(0.22)	(1.05)	(0.67)
26	0.037*	–0.004	0.022	–0.002	–0.006	0.001
	(2.99)	(0.52)	(1.34)	(0.18)	(1.20)	(0.61)
27	0.025*	–0.012	0.009	–0.010	–0.003	0.005*
	(2.05)	(1.63)	(0.54)	(1.20)	(0.67)	(2.08)
28	0.029*	0.004	0.015	0.006	–0.004	–0.000
	(2.43)	(0.48)	(0.95)	(0.77)	(1.03)	(0.21)
29	0.028*	0.000	0.027	0.013	–0.002	0.003
	(2.49)	(0.02)	(1.84)	(1.62)	(0.50)	(1.38)
30	0.034*	0.003	0.028	–0.002	–0.005	0.001
	(3.11)	(0.45)	(1.94)	(0.21)	(1.13)	(0.53)
31	0.021	–0.012	0.028	0.001	–0.004	0.000
	(1.95)	(1.59)	(1.97)	(0.14)	(1.11)	(0.13)
32	0.031*	0.010	0.014	–0.007	–0.005	0.001
	(2.86)	(1.31)	(1.02)	(0.80)	(1.25)	(0.45)
33	0.027*	–0.002	0.023	0.014	–0.000	0.005*
	(2.61)	(0.27)	(1.84)	(1.72)	(0.11)	(2.33)
34	0.041*	0.008	0.038*	0.022*	0.002	0.003
	(4.15)	(1.11)	(3.20)	(2.60)	(0.48)	(1.29)
35	0.030*	–0.011	0.026*	–0.009	0.002	0.001
	(3.53)	(1.56)	(2.53)	(1.05)	(0.61)	(0.31)
36	0.030*	0.014	0.015	–0.009	0.005*	0.006*
	(4.80)	(1.84)	(1.93)	(0.99)	(2.28)	(2.42)
Sum of Lags	1.078*	.049	0.582	.110	– .278*	.071*
	(3.62)	(0.77)	(1.48)	(1.17)	(2.06)	(3.12)
F[1]	1.88*	1.38	1.62*	1.49	1.65*	1.97*
$\bar{R}^2$	.35	.27	.31	.29	.32	.37
SEE	.2288	.2435	.2362	.2400	.2351	.2265

*Indicates statistical significance at the 5 percent level.

[1]F – statistic for the joint significance of the monetary variables.

Table 6

Estimates of Equation 16: 1973.10 − 1987.06

Lag	$\Delta\dot{M}1$	$\Delta M1-\Delta M1^e$	$\Delta\dot{MB}$	$\Delta MB-\Delta MB^e$	$\Delta N\dot{B}R$	$\Delta NBR-\Delta NBR^e$
Constant	−.046	−.058	−.028	.001	.020	−.029
	(0.92)	(0.94)	(0.52)	(0.01)	(0.36)	(0.40)
0	−0.008	−0.002	0.039*	0.049	−0.013*	−0.013*
	(0.99)	(0.20)	(2.18)	(1.97)	(4.65)	(3.28)
1	0.050*	0.062*	0.094*	0.029	−0.010*	−0.000
	(4.58)	(5.44)	(3.69)	(1.11)	(3.04)	(0.06)
2	0.044*	−0.005	0.100*	−0.002	−0.005	0.004
	(3.17)	(0.40)	(3.02)	(0.09)	(1.43)	(1.09)
3	0.055*	0.020	0.111*	0.030	−0.008	0.004
	(3.65)	(1.53)	(2.92)	(1.14)	(1.97)	(1.02)
4	0.039*	0.000	0.070	−0.052	−0.007	0.002
	(2.37)	(0.01)	(1.73)	(1.93)	(1.53)	(0.37)
5	0.045*	0.008	0.082*	0.085*	−0.011*	−0.002
	(2.58)	(0.58)	(2.01)	(3.11)	(2.25)	(0.55)
6	0.042*	0.024	0.076	0.020	−0.011*	0.001
	(2.33)	(1.75)	(1.94)	(0.66)	(2.04)	(0.28)
7	0.032	0.006	0.060	−0.033	−0.010	0.000
	(1.94)	(0.39)	(1.60)	(1.11)	(1.72)	(0.02)
8	0.030	0.016	0.032	−0.006	−0.010	0.002
	(1.82)	(1.15)	(0.86)	(0.21)	(1.62)	(0.59)
9	0.031	−0.001	0.033	0.028	−0.009	−0.002
	(1.84)	(0.10)	(0.89)	(1.05)	(1.43)	(0.58)
10	0.026	0.002	0.040	−0.005	−0.011	−0.002
	(1.54)	(0.17)	(1.08)	(0.20)	(1.65)	(0.46)
11	0.041*	0.014	0.047	0.014	−0.010	−0.000
	(2.33)	(1.05)	(1.28)	(0.55)	(1.49)	(0.10)
12	0.040*	−0.003	0.056	0.030	−0.005	0.005
	(2.20)	(0.21)	(1.55)	(1.17)	(0.74)	(1.26)
13	0.013	−0.034*	0.034	−0.014	−0.008	−0.002
	(0.71)	(2.55)	(0.96)	(0.56)	(1.20)	(0.42)
14	0.020	0.005	0.053	0.056*	−0.008	−0.004
	(1.11)	(0.34)	(1.50)	(2.25)	(1.15)	(1.05)
15	0.028	0.012	0.043	0.026	−0.008	−0.001
	(1.57)	(0.82)	(1.21)	(1.00)	(1.13)	(0.38)
16	0.013	−0.014	0.059	0.021	−0.008	−0.000
	(0.71)	(0.98)	(1.69)	(0.83)	(1.08)	(0.11)
17	0.022	0.020	0.066	−0.012	−0.007	−0.003
	(1.22)	(1.39)	(1.94)	(0.48)	(0.94)	(0.70)
18	0.036*	0.002	0.082*	0.041	−0.011	−0.007
	(2.00)	(0.14)	(2.42)	(1.66)	(1.48)	(1.77)
19	0.044*	0.008	0.091*	0.001	−0.009	−0.002
	(2.44)	(0.57)	(2.68)	(0.04)	(1.27)	(0.42)

Lag	$\Delta\dot{M}1$	$\Delta M1-\Delta M1^e$	$\Delta\dot{MB}$	$\Delta MB-\Delta MB^e$	$\Delta N\dot{B}R$	$\Delta NBR-\Delta NBR^e$
20	0.032	−0.018	0.093*	0.003	−0.006	0.002
	(1.73)	(1.29)	(2.68)	(0.12)	(0.80)	(0.50)
21	0.031	−0.013	0.086*	0.007	−0.009	−0.003
	(1.65)	(0.96)	(2.43)	(0.29)	(1.25)	(0.86)
22	0.044*	0.000	0.101*	0.013	−0.010	−0.003
	(2.37)	(0.01)	(2.84)	(0.54)	(1.30)	(0.67)
23	0.039*	0.003	0.077*	−0.011	−0.009	−0.006
	(2.08)	(0.22)	(2.12)	(0.49)	(1.27)	(1.49)
24	0.026	−0.009	0.069	0.022	−0.011	−0.003
	(1.35)	(0.65)	(1.88)	(0.94)	(1.49)	(0.88)
25	0.022	0.003	0.067	0.032	−0.006	0.008
	(1.18)	(0.22)	(1.81)	(1.40)	(0.86)	(1.93)
26	0.018	−0.011	0.059	−0.032	−0.008	−0.005
	(0.99)	(0.79)	(1.57)	(1.37)	(1.15)	(1.19)
27	0.012	−0.003	0.046	−0.008	−0.011	−0.005
	(0.69)	(0.20)	(1.21)	(0.36)	(1.60)	(1.17)
28	0.014	−0.001	0.041	−0.018	−0.009	−0.002
	(0.78)	(0.08)	(1.06)	(0.78)	(1.44)	(0.42)
29	0.016	0.003	0.037	−0.001	−0.010	−0.002
	(0.93)	(0.19)	(0.97)	(0.03)	(1.55)	(0.55)
30	0.015	−0.011	0.024	−0.020	−0.007	−0.003
	(0.90)	(0.87)	(0.66)	(0.87)	(1.20)	(0.62)
31	0.014	−0.002	0.028	0.022	−0.007	0.003
	(0.92)	(0.17)	(0.81)	(0.94)	(1.23)	(0.66)
32	0.018	0.012	0.013	−0.001	−0.007	−0.001
	(1.19)	(0.94)	(0.41)	(0.06)	(1.29)	(0.32)
33	0.009	0.000	0.014	−0.007	−0.007	−0.003
	(0.70)	(0.00)	(0.49)	(0.31)	(1.47)	(0.74)
34	0.015	0.010	−0.002	−0.007	−0.002	0.004
	(1.31)	(0.75)	(0.09)	(0.30)	(0.53)	(0.97)
35	0.006	−0.003	0.009	0.007	0.001	−0.001
	(0.57)	(0.21)	(0.42)	(0.33)	(0.26)	(0.30)
36	0.011	0.017	0.003	−0.016	−0.003	−0.004
	(1.26)	(1.31)	(0.19)	(0.69)	(0.83)	(0.73)
Sum of Lags	0.986*	.115	2.034*	.289*	−0.298	−.044
	(2.38)	(1.82)	(2.33)	(2.00)	(1.74)	(1.28)
F[1]	2.24*	1.72*	1.10	1.16	1.10	1.12
$\bar{R}^2$	.40	.40	.24	.30	.24	.30
SEE	.6137	.6595	.6891	.7109	.6895	.7149

*Indicates statistical significance at the 5 percent level.

[1]F-statistic for the joint significance of the monetary variables.

Table 7
Results of the Davidson-MacKinnon J-test

Null/Alternative Hypotheses	Estimation Periods 1959.08–1987.06	1959.08–1973.09	1973.10–1987.06
$\Delta\dot{M}1/\Delta\dot{M}B$	−.87	.12	−1.02
$\Delta\dot{M}B/\Delta\dot{M}1$	3.78*	.33	3.58*
$\Delta\dot{M}1/\Delta N\dot{B}R$	3.15*	.20	2.53*
$\Delta N\dot{B}R/\Delta\dot{M}1$	3.36*	.31	3.03*
$\Delta\dot{M}B/\Delta N\dot{B}R$	3.59*	.18	3.02*
$\Delta N\dot{B}R/\Delta\dot{M}B$	−.86	.04	−.50
$(\Delta M1-\Delta M1^e)/(\Delta MB-\Delta MB^e)$	3.59*	.03	2.72*
$(\Delta MB-\Delta MB^e)/(\Delta M1-\Delta M1^e)$	.01	1.61	1.46
$(\Delta M1-\Delta M1^e)/(\Delta NBR-\Delta NBR^e)$	6.29*	2.83*	4.15*
$(\Delta NBR-\Delta NBR^e)/(\Delta M1-M1^e)$	−2.25*	0.53	−.75
$(\Delta MB-\Delta MB^e)/(\Delta NBR-\Delta NBR^e)$	6.22*	3.36*	4.25*
$(\Delta NBR-\Delta NBR^e)/(\Delta MB-\Delta MB^e)$	2.01*	−1.37	1.73

*Indicates statistical significance at the 5 percent level.

Estimates of Equation 13

As a further test of the robustness of the results to the model specification, equations of the general form of equation 13 are estimated. This specification has been estimated in such diverse ways and with such a wide array of regressors that an exhaustive evaluation is difficult. Instead, the approach here relies on the fact that this specification differs from the others primarily in that it has been estimated in *level*, rather than first-difference, form.[34] Some studies include measures of expected and unexpected inflation and unanticipated money growth; others include expected inflation, some measure of income growth, and a measure of the change in the growth rate of money. In the former studies, inflation expectations are generated as they are in the rational expectations models; in the latter, they are usually derived from survey data. Furthermore, Mehra (1985) and Wilcox (1983 a,b) measure the change in the money supply by the annualized growth rate of money over a shorter period relative to its growth rate over a longer period.

Consequently, two equations are estimated to capture the essence, if not the exact form, of variations of this specification. These equations are

$$(17)\ TBR_t = \alpha_0 + \sum_{i=1}^{6} \alpha_i TBR_{t-i} + \beta LIQ_t + \mu\Delta\dot{P}_t + \delta\Delta y_t + \lambda\dot{P}_t + \varepsilon_t$$

and

$$(18)\ TBR_t = \alpha_0 + \sum_{i=1}^{6} \alpha_i TBR_{t-i} + \beta(\Delta MV-\Delta MV^e)_t + \mu(\Delta P-\Delta P^e)_t + \delta(\Delta y-\Delta y^e)_t + \Delta P^e_t + \varepsilon_t.$$

LIQ is the negative of the difference between the annualized growth rate of M1 during the last three months and its annualized growth rate over the prior 12 months, $\Delta\dot{P}$ is the change in the growth rate of the price level and Δy is the change in level of the industrial production index. Because equation 18 includes ΔP^e_t, the estimated standard errors of ΔP^e_t from the usual two-step estimator of equation 18 are biased. Consequently, equation 18 is estimated using a full-information, maximum-likelihood (FIML) method used by Mishkin (1981, 1982).[35]

[34]One exception to this is Peek who, although he specified the equation in level form, appears to have estimated it in first-difference form. See Peek (1982) p. 986.

[35]Equation 18 is estimated simultaneously with the equations that generate the expected rates of monetary growth, inflation and real output growth, imposing the implied cross-equation restrictions. Also, because equation 18 includes a distributed lag of the level of TBR, the equations used to generate these expectations are modified to include the level of interest rates.

Table 8
Estimates of Equation 17

MV^u	Constant	LIQ	$\Delta\dot{P}$	Δy^1	$\dot{P}^1$	$\bar{R}^2$	SEE
			1960.05 – 1987.06				
M1	−.003	.034*	−.004	.067*	.040*	.970	.5141
	(0.04)	(4.25)	(0.37)	(3.38)	(3.92)		
MB	−.028	.051*	−.003	.077*	.042*	.970	.5185
	(.38)	(3.53)	(0.27)	(3.87)	(4.16)		
NBR	.035	−.003	−.003	.068*	.044*	.970	.5264
	(.047)	(1.67)	(0.29)	(3.30)	(4.23)		
			1960.05 – 1973.09				
M1	.145	.006	−.011	.006	.034*	.975	.2443
	(1.88)	(0.86)	(1.35)	(0.47)	(2.72)		
MB	.156*	.000	−.011	.006	.034*	.973	.2449
	(2.01)	(0.02)	(1.29)	(0.48)	(2.70)		
NBR	.151*	−.005	−.011	−.001	.032*	.974	.2420
	(2.01)	(1.93)	(1.29)	(0.10)	(2.55)		
			1973.10 – 1987.06				
M1	−.085	.042*	−.000	.131*	.049*	.944	.6732
	(0.44)	(3.27)	(0.01)	(3.34)	(3.04)		
MB	−.153	.091*	−.002	.144*	.052*	.947	.6703
	(0.79)	(3.48)	(0.09)	(3.72)	(3.31)		
NBR	−.046	−.002	.001	.146*	.056*	.940	.6947
	(0.23)	(0.81)	(0.06)	(3.55)	(3.43)		

[1]Since the coefficients on these variables are hypothesized to be positive, the significance tests are one-tailed.
*Indicates statistical significance at the 5 percent level.

Table 8 presents estimates of equation 17.[36] The results indicate that interest rates show no statistically significant negative response; however, the coefficient for NBR for the pre-1974 period is nearly significant at the 5 percent level. The significant positive relation between LIQ and the level of the Treasury bill rate during the entire period, when either M1 or MB is the monetary variable, is attributable solely to the post-1973 period.

The magnitude of the coefficients on $\Delta\dot{P}$ and Δy and, in the case of Δy its statistical significance, depends on the period. The positive coefficient on $\dot{P}$ is statistically significant regardless of the sample period; however, the estimated magnitude of the coefficient is sensitive to the sample period.

Table 9 presents estimates of equation 18. Unanticipated inflation is significant in all three periods only when NBR is the monetary variable. Both unanticipated income and inflation are significant during the post-1973 period for all monetary variables. Surprisingly, anticipated inflation is signifi-

[36]Some econometric issues should be addressed because equations are estimated in both level and first-difference form. The issues center around whether the variables on both the left- and right-hand sides of the equations are stationary. If the right-hand-side variables are non-stationary, then the reported standard errors from the level equation will be incorrect even if the left-hand-side variable is stationary. On the other hand, if both the left- and right-hand-side variables are stationary, the reported standard errors from the first-difference specification will be inconsistent because the error term from this equation will be serially correlated. Most tests of macroeconomic time-series variables, like the ones used here, suggest that they are not stationary in the levels, e.g., Nelson and Plosser (1982); however, these tests are not powerful against the alternative hypothesis that the data are generated by a stationary AR process with close to a unit root. In this instance, estimates of the level equation would be appropriate, though the sample size necessary for appropriate inferences might be large. Because the objective is to see whether the results are sensitive to the specification of the equation, we are agnostic about whether the level or first-difference specification is "best."

Because of the lags involved in the construction of LIQ, it was necessary to shorten the estimation period for the first two periods. They begin at 1960.05, rather than 1958.07.

Table 9

FIML Estimates of Equation 18 for the three periods

MV^u	Constant	$\Delta MV - \Delta MV^e$	$\Delta P - \Delta P^e$ [1]	$\Delta y - \Delta y^e$ [1]	ΔP^e
			1959.08 – 1987.06		
M1	.060	−.008	.009	.008*	.069*
	(0.95)	(1.58)	(0.93)	(3.26)	(5.77)
MB	.054	.016	.050*	.011*	.018
	(0.81)	(1.94)	(4.51)	(4.31)	(1.46)
NBR	.081	−.011*	.039*	.009*	.013
	(1.24)	(6.68)	(3.71)	(3.65)	(1.03)
			1959.08 – 1973.09		
M1	.189*	.009	.014	.000	.059*
	(2.69)	(1.62)	(1.49)	(0.00)	(3.54)
MB	.183*	.003	.013	.001	.061*
	(2.55)	(0.48)	(1.28)	(0.42)	(3.73)
NBR	.144*	−.003*	.024*	.002	.024
	(2.08)	(2.10)	(2.51)	(1.09)	(1.58)
			1973.10 – 1987.06		
M1	−.188	−.027*	.105*	.021*	−.034
	(0.91)	(3.43)	(6.19)	(4.33)	(1.61)
MB	−.020	.036*	.083*	.021*	−.013
	(0.08)	(2.32)	(4.38)	(4.06)	(0.68)
NBR	.193	−.015*	.058*	.010*	.000
	(1.08)	(5.60)	(3.13)	(1.92)	(0.02)

[1]Since the coefficients on these variables are hypothesized to be positive, the significance tests are one-tailed.
*Indicates statistical significance at the 5 percent level.

cant only during the pre-1974 period, and then only when M1 or MB is used.

With respect to the responsiveness of interest rates to monetary changes, the results are consistent with those reported in tables 1–6. A significant negative effect is obtained during all three periods only when NBR is the monetary variable. Moreover, the effect is larger during the post-1973 period, when a significant negative effect is also obtained with M1 as the monetary variable. Hence, the results are similar whether the interest rate is specified in level or first-difference form.

The Responsiveness of Interest Rates and Monetary Control

The responsiveness of interest rates should be greatest during periods when the Federal Reserve is attempting to control money. Since the Fed was attempting to control M1 through a nonborrowed-reserves operating procedure from October 1979 to October 1982, more precise estimates of the responsiveness of interest rates should be obtained during this period. The limited number of monthly observations prevents using specifications with a large number of parameters; however, the number of observations can be expanded by employing weekly data. The weekly time period has the added advantage that the responsiveness of interest rates to monetary changes is even less likely to be contaminated by income and inflation expectations effects.

Unfortunately, using weekly data precludes the income and price variables.[37] Previous results, however, indicate that a statistically significant

[37]Cunningham (1987) and Cunningham and Hardouvelis (1987) also use weekly data and proxy changes in prices by the BLS 22-commodity spot price index and income by unemployment claims. They acknowledge the weakness of these proxies and report no direct evidence consistent with a strong response of interest rates.

Table 10

Estimates of Equation 15 Using Monthly Data: 1979.10 – 1982.09

MV^{u}	Constant	MV^{u}	yV^{u1}	PV^{u1}	$\bar{R}^2$	SEE
$\Delta\dot{M}1$	.018	−.040*	.023	.086	.341	1.2533
	(0.08)	(2.03)	(1.13)	(1.49)		
	.002	−.038	—	—	.300	1.2930
	(0.01)	(1.88)				
$\Delta\dot{M}B$	.017	.007	.026	.069	.238	1.3485
	(0.07)	(0.15)	(1.17)	(1.06)		
	.008	.018	—	—	.215	1.3682
	(0.04)	(0.39)				
$\Delta N\dot{B}R$	.006	−.041*	.029*	.039	.610	.9650
	(0.04)	(4.98)	(1.84)	(0.88)		
	.004	−.041*	—	—	.576	1.0061
	(0.02)	(4.91)				
$(\Delta M1-\Delta M1^{e})$	.063	−.040	.021	.162*	.256	1.3320
	(0.28)	(1.09)	(0.79)	(1.78)		
	.006	.017	—	—	.218	1.3661
	(0.03)	(0.49)				
$(\Delta MB-\Delta MB^{e})$	.029	.094	.046*	.164*	.398	1.1984
	(0.14)	(1.22)	(1.95)	(1.78)		
	.087	.157*	—	—	.323	1.2707
	(0.40)	(2.15)				
$(\Delta NBR-\Delta NBR^{e})$	.109	−.053*	.035*	.106	.606	.9698
	(0.66)	(4.47)	(1.89)	(1.64)		
	.065	−.057*	—	—	.545	1.0416
	(0.37)	(4.53)				

[1]Since the coefficients on these variables are hypothesized to be positive, the significance tests are one-tailed.

*Indicates statistical significance at the 5 percent level.

effect is just as likely to show up in relatively simple and parsimonious specifications like equation 15. Also, the results indicate that the significance of the effect is relatively unaffected by the form of the unanticipated monetary variable. Consequently, specifications like equations 15 and 16 (without the price and income variables) can be used to estimate the responsiveness of interest rates to changes in the money stock with weekly data.

Estimates of equation 15 using monthly data for the period from 1979.10 to 1982.09 are presented in table 10. They are similar to those for the post-1973 period. When $\Delta\dot{M}1$ is the unanticipated monetary variable, the coefficient is negative and significant at the 5 percent level if unanticipated output and inflation are included, and marginally insignificant if they are not. For MB, the coefficient is positive and statistically significant only if $(\Delta MB - \Delta MB^{e})$ is used and the other variables are excluded. When NBR is used, however, the coefficient is negative and highly significant regardless of whether the other variables are included. Furthermore, the estimated coefficients are larger than those obtained for the entire post-1973 period, and the adjusted R^2 is about twice that of the other monetary aggregates. These results are in keeping with the nonborrowed-reserves operating procedure used during the period. Nevertheless, the coefficients are small, indicating that a 1 percent increase in the growth rate of nonborrowed reserves results in an about four to six basis points decline in the monthly Treasury bill rate.[38]

Table 11 presents results using weekly data.[39]

[38]See Thornton (1988) for a discussion of the borrowed-reserves operating procedure.

[39]An equation similar to 16 was also estimated using weekly data. The results are not qualitatively different from those reported in table 11.

Table 11

Estimates of Equation 15 Using Weekly Data: October 3, 1979–October 6, 1982.

Monetary Variable	Constant	MV^u	$\bar{R}^2$	SEE
$\Delta\dot{M}1$	−.008	−.000	.085	.5843
	(0.18)	(0.30)		
$\Delta\dot{M}B$	−.008	−.000	.084	.5844
	(0.18)	(0.11)		
$\Delta N\dot{B}R$	−.008	−.000	.090	.5826
	(0.18)	(0.97)		
$(\Delta M1 - \Delta M1^e)$	−.008	−.002	.088	.5831
	(0.18)	(0.82)		
$(\Delta MB - \Delta MB^e)$	−.008	−.001	.084	.5843
	(0.18)	(0.27)		
$(\Delta NBR - \Delta NBR^e)$	−.008	−.001	.098	.5801
	(0.18)	(1.50)		

*Indicates statistical significance at the 5 percent level.

There is no statistically significant response of equation 15 without the price and income variables, regardless of the monetary variable used. The results suggest that interest rates do not respond over a period as short as a week, but do respond over a period as long as a month.[40]

One possible reason for the disparity between the weekly and monthly results is that the data are averages of daily figures and the averaging process might mask the response of interest rates when weekly data are used.[41] Consequently, the equations using weekly data were re-estimated with the change in the Treasury bill rate measured by the difference in the Treasury bill rate on consecutive Wednesdays. Though not reported here, the results are qualitatively the same as those shown in table 11. Consequently, the insignificant response of interest rates is not due to averaging.

SUMMARY AND CONCLUSIONS

This article estimates the responsiveness of interest rates to monetary changes using alternative specifications that have been used in the literature and alternative monetary variables. The equations are estimated over the same time periods using the same data. Several interesting results emerge from this study.

First, estimates of the response of interest rates are relatively insensitive to the specification employed; they are, however, sensitive to the monetary variable used. A significant negative response of interest rates is most likely obtained if nonborrowed reserves is used as the monetary variable.

Second, a negative and statistically significant relationship between M1 or nonborrowed reserves and interest rates is more likely to be obtained during periods when the Fed was placing greater emphasis on monetary aggregates. The most consistent and statistically significant negative effect is obtained using nonborrowed reserves, a monetary variable that is likely to reflect the independent actions of the Federal Reserve. Nevertheless, the fact that there is a significant effect using nonbor-

[40]Hardouvelis (1987) estimates an equation similar to equation 16 using quarterly data for the period 1979.04 to 1982.03 and reports a very large negative and statistically significant effect of unanticipated money on the three-month Treasury bill rate. He finds no significant effect for the 11 quarters prior to 1979.04 or during the 12 quarters after 1982.03. He interprets this as evidence of a strong liquidity effect during the period when the Fed was targeting the money stock. Since he does not adjust for the credit controls during the first and second quarters of 1980, however, his atypically large interest rate response may be due to unusual movements in money and interest rates during these quarters. For example, the money stock decreased at a 5.9 percent annual rate during the first quarter of 1980, while the three-month Treasury bill rate increased by 316 basis points (measured as Hardouvelis does from the last month of the quarter). The money supply increased at a 21 percent rate during the second quarter of 1980 and the Treasury bill rate declined by 813 basis points.

[41]The monthly data used here are also averages of daily figures. Mishkin (1982) argues that misleading results about market efficiency can be obtained using averaged data, and reports that he obtained substantially worse fits when he estimated his equations using quarterly averaged data.

rowed reserves regardless of whether the Fed is concerned about the money stock or interest rates is anomolous.

Third, estimates of the responsiveness of interest rates are sensitive to the time period chosen. Generally, there is no statistically significant response of interest rates from 1958.08 to 1973.09 regardless of the monetary variable used. In contrast, a statistically significant negative effect is obtained using both M1 or nonborrowed reserves after 1973.09.

Fourth, the results are sensitive to the periodicity of the data. In particular, in the specifications estimated over the period from October 1979 to October 1982, there is a significant negative effect when monthly nonborrowed reserves are used, but not when weekly nonborrowed reserves are used.

Finally, the evidence shows that even when there is a significant negative response of interest rates, the measured response is small.

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