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By

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LONG- AND SHORT-TERM INTEREST RATES IN A RISKY WORLD*

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The paper develops and tests a general equilibrium model in which variability, or risk, affects the choice of portfolios. Our measures of variability include only the variability of unanticipated growth in monetary and non-monetary aggregates, and our tests use data ending with the change in Federal Reserve procedures in October 1979. We find that increased variability of unanticipated money growth raises demands for debt and money, and reduces the demand for real capital. Interest rates on both short- and long-term debt rise by a risk premium. We estimate the size of the risk premium before and after the October 1979 change, and we show that the change in Federal Reserve procedures moved the economy to a less efficient point.

1. Introduction

Five approaches to the study of interest rates and asset prices are in common use. Most common in theoretical work is the Keynes-Hicks-Metzler model, known familiarly as IS-LM. Most common in empirical work is either the so-called Fisher equation or some version of the capital asset pricing-efficient markets equation. A fourth approach emphasizes the equilibrium of the balance sheet and the choice between money, bonds and real capital. A fifth analyzes the portfolio choices of individual lenders and borrowers in the bond market.

Each approach has proved useful for certain classes of problems, and each has limitations. The IS-LM model, augmented by a production constraint and some type of Phillips curve, is the simplest general equilibrium framework that captures the principal relations of macroeconomics. The standard version has only one real interest rate and, at most, one expected rate of inflation and one nominal rate. The restriction to one real and nominal interest rate implies that all changes in that rate are either changes

*This study was carried out while Meltzer was a consultant to the Treasury Department but does not represent the views of the department. The authors wish to thank Beryl Sprinkel and Denis Karnosky for support, encouragement and prodding and Karl Brunner, Alex Cukierman, Benjamin M. Friedman, Victoria Farrell, Ray Lombra and Robert Rasche for helpful discussions and comments.

in holding period yields or changes in the equilibrium, market clearing rate. A common assumption, to avoid this difficulty, is that all real capital is financed by bonds with one period to maturity. The assumption avoids treating the term structure of interest rates, ignores fluctuations in the relation of short- to long-term rates, and neglects cyclical differences in returns to real and nominal assets at different maturities arising, for example, from a mix of persistent and transitory changes in real variables.

Multi-equation, econometric models, based on IS-LM usually assume that rates for different maturities and risks are determined sequentially. One rate, usually a short-term rate, is determined by policy actions. Other rates depend on the first. This procedure does not distinguish between persistent and transitory influences efficiently, and it fails to separate the influence of impulses that change rates at different maturities in opposite directions from forces that change these rates in the same direction.

Variants of the efficient markets model have been used to estimate equations for the term structure of interest rates and the real rate of interest by a number of writers beginning with Roll (1970). Early studies assume there is a riskless real rate at which people hold 'safe assets'. More recent work by Shiller (1979), Singleton (1980) and Mishkin (1981) uses rational expectations, in the sense of Muth, to estimate equations for interest rates. Shiller and Singleton reject the expectations model for the term structure, and Mishkin (1981) rejects the constancy of the real rate of interest. Brennan and Schwartz (1982) report evidence of the effect of market risk on government bond prices using an intertemporal asset pricing model to determine the prices of short- and long-term bonds. Some authors find evidence of a variable risk premium, but neither the risk premium nor fluctuations in the term structure have been incorporated in a structural model or related to other variables of a general equilibrium model.

Most recent work rejects the simple version of the Fisher equation relating nominal rates of interest to the rate of inflation. Various reasons are given including taxes, Darby (1975) and Feldstein (1976), the effect of inflation on the real rate of interest, Mundell (1963), and fluctuations in inventories and economic activity caused by the inability to forecast the duration or persistence of shocks to money and output, Cukierman (1981).

Hartman and Makin (1982) introduce the effect of uncertainty about inflation into the Fisher equation. They show that risk neutral and risk averse investors incorporate the mean and variance of inflation, not just the expected rate of inflation, into interest rates. Further, they show that risk

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1See Hunt (1976) or Pierce and Thomson (1974) for examples. A critique of the procedure is Anderson and Rasche (1982).

2In our preliminary work on this topic, we introduced measures of variability into a Fisher equation. The results are reported and criticized in Volcker (1982).

3Romer (1981) finds no effect of individual tax rates on government security yields.
aversion can explain the typical finding that the coefficient of expected inflation on the nominal rate is less than unity.\footnote{Cukierman (1983) surveys work on the effects of variable inflation.}

Brunner and Meltzer (1968a), Zwick (1971), and Korteweg and van Loo (1977) estimated equations derived from a theory of asset markets, in which bonds are a less than perfect substitute for money and real capital. Their estimates suggest that Tobin's (1961) suggestion is correct; the responses of interest rates to debt differ from the response to money and real capital. Although the point is acknowledged frequently, it has had little influence on subsequent empirical work on the effect of debt finance.\footnote{Some exceptions are Eckstein and Feldstein (1970), Stein (1976) and Zwick (1971) do not find a statistically significant effect of debt on output or market interest rates respectively. Eckstein and Feldstein (1970), and Korteweg and van Loo (1977) report significant (positive) effects of debt on interest rate, but Chamberlain and Feldstein (1973) do not find significant effects. A more recent study, Plosser (1982), finds no effect of debt on interest rates.} These models do not incorporate any measure of risk or variability, however.

Friedman (1977, 1980) and Roley (1981) analyze the portfolio choices of individual lenders and borrowers in the bond market. Using a partial equilibrium model that relates asset demands to inflation, interest rates, financial wealth and measures of variability, Friedman (1980) finds negative effects of the variance of interest rates and the variance of inflation in the equations for some lenders. Roley (1981) finds significant effects of interest rate variability on the term structure of interest rates.

The studies cited above, and others, are part of a larger body of evidence — much of it from the field of finance — suggesting that there is a relation between measures of risk or variability and asset demands. A very different body of work, recently surveyed by Cukierman (1983), finds a systematic relation between inflation and the variability of relative prices. Little has been done either to integrate these findings on the role of risk or variability into macroeconomics or to relate portfolio risk and variability to policy variables and real shocks. This study is a first step to partially fill that gap.

Recent events heighten interest in possible policy implications of changes in variability. The Federal Reserve's decision in October 1979 to alter procedures for controlling money was followed by an increase in the variability of money and in the average level and variability of interest rates at all maturities. The Federal Reserve study of the first year under the new operating procedures reports on the increase in the variability of money and interest rates but provides no explanation for the increase in variability at all maturities. [Board of Governors (1981).] On the contrary, the studies that discuss variability usually treat the issue as a trade-off between the variability of money growth and the variability of interest rates. This is counter-factual, at least for the first two years of operations under the revised procedures. Further, if the increased variability that followed the change in policy procedures contributed to the higher average level of interest rates, it may be
possible to reduce the level of interest rates, the variability of money growth and the variability of interest rates by changing control procedures.

This paper develops a general equilibrium model in which variability or risk affects the choice of portfolios. Debt, money and capital are treated as distinct assets. The demand for each asset responds to risk, return, output and prices and to monetary and fiscal policy, so real and market interest rates depend on perceived risk and government policies. Risk is not constant but varies with the variability of unanticipated rates of change in monetary and real variables. Rational expectations, in the sense of Muth, are used in our tests.

The remainder of the paper consists of five sections. Section 2 discusses the role of risk and the measures of risk used in the paper, then introduces the measure of risk into a standard IS-LM model. This model determines one interest rate, so it cannot distribute the effects of increased risk over short- and long-term rates or account for what is commonly described as the 'high-level of real rates' on short- and long-term debt observed in recent years. Section 3 develops a structural model with markets for money, securities, goods and real capital and derives comparative statics results for short- and long-term interest rates. Section 4 tests for the effect of variability or risk on interest rates. Sections 5 and 6 discuss effects of recent changes in monetary policy procedures, deficits, and other implications and limitations of the model. A conclusion completes the paper. An appendix available from the author describes the estimation procedure in more detail.

2. The measurement and effect of risk

In a world of certainty, or certain expectations, people know either the mean income, price level and rate of inflation or the expected values of these variables for all periods into the future. Fluctuations are known to be, and are perceived as, transitory deviations from mean values. As in the standard model of rational expectations, Lucas (1972), relative prices can change, but changes are not expected to persist. Expected values of output or its rate of change are known, and risk is constant. There is no uncertainty about the stochastic structure.

A rather different view is offered by Keynes (1936), and by Friedman and Schwartz (1963). Keynes's precautionary demand for money relates the quantity of money demanded to the 'desire for security' (1936, p. 170). According to Keynes (ibid. p. 171), precautionary demand is not very sensitive to the rate of interest. Changes in precautionary demand affect the rate of interest, however, by changing the demand for money. Friedman and

6Alternative portfolio approaches are Eden (1976) and Fischer (1975). See also Cosimano (1982).

7An excellent survey by McCallum (1980) discusses the major developments.
Schwartz's discussion of the postwar increase in monetary velocity is more explicit. After rejecting several, partial explanations of the rise in measured velocity from 1946 to 1960, Friedman and Schwartz (1963, p. 673) write: "It is highly plausible that the fraction of their assets individuals and business enterprises wish to hold in the form of money, and also in the form of close substitutes for money, will be smaller when they look forward to a period of stable economic conditions than when they anticipate disturbed and uncertain conditions." A few pages later, (ibid., p. 675), Friedman and Schwartz tentatively accept the proposition that improved confidence about economic stability induced a shift from money to other assets during the fifties. This shift reduced money per unit of income and raised monetary velocity.

2.1. Risk in an IS-LM model

One main hypothesis of this paper starts from the conjectures of Keynes and of Friedman and Schwartz about the effect of increased or reduced stability. We assume that, in a less stable, more variable, environment, people choose to hold more money and less of other assets, so there is a positive association between variability and the demand for money. To analyze the effects on interest rates and other variables, we introduce a risk variable in the IS-LM model by including risk in the demand for money. In an IS-LM model, the only other asset is capital (or claims to real capital). If increased risk raises the demand for money, it reduces the demand for capital and produces a one-time reduction in prices and a rise in the real rate of interest.

Eqs. (1) and (2) constitute a type of IS-LM model with shocks, \( \theta \) and \( \mu \), written explicitly. \( B \) is the stock of base money (the monetary base), and \( d \) is real aggregate demand for goods and services. The signs above the variables indicate the signs of partial derivatives.

\[
B + \mu = b ( \bar{i}^+ , y^+, \sigma^+ ) p + \theta, \quad 0 < \theta < 1, \tag{1}
\]

\[
d = d ( \bar{i}^-, \pi^+, y, B/p ) + g. \tag{2}
\]

To close the model, we introduce an aggregate supply equation similar to the type used by Lucas (1972) and others. The stochastic structure is not fixed, however; output is governed by an exogenous stochastic process summarized by \( \epsilon \),

\[
y = y^e + \epsilon. \tag{3}
\]

In equilibrium, \( y = d + g \), so (2) and (3) can be combined. The market rate of interest, \( i \), the levels of actual real \( (y) \) and expected \( (y^e) \) income, the price
level, \( p \), the anticipated rate of inflation, \( \pi \), and real government spending, \( g \), affect the markets for money and output in conventional ways.

There are three shocks; \( \mu \) and \( \theta \) are shocks to the stock of money and the demand for money; \( \varepsilon \) is the shock to aggregate supply. A shock to output changes output and spending, and thus, affects the demands for assets. Through \( \mu, \varepsilon \) and \( \theta \), all shocks affect the market rate of interest, \( i \), the demand for money and the stock of money. Positive \( \mu \) lowers interest rates, and positive \( \theta \) raises interest rates, ceteris paribus.

A second hypothesis of the paper is that the variability of government policies affects the risk that individuals and society bear. Policies may be well-defined and precise, or flexible and ill-defined. Less predictable policies increase risk by making policy outcomes less certain. Methods of implementing policies also affect risk by increasing or reducing doubts about the government's intentions to persist in pre-announced policies or more generally to carry out commitments. The presence of \( \sigma \) as an argument in the demand for money reflects the negative effect of increased policy stability (or the positive effect of increased variability) on the demand for money.

Government policies are not the only source of variability.\(^8\) Risks in nature and risks arising from private decisions affect output, prices and asset demands. Decisions of foreign governments to change the price of oil, to float their currencies or to intervene in the foreign exchange market alter the level of risk and the type borne by owners of domestic assets. Increases in variability from these sources, and others, also raise \( \sigma \).

Fig. 1 shows the effect of an increase in \( \sigma \) on the equilibrium values of \( i \) and \( y \) derived from eqs. (1) to (3). The initial equilibrium at the intersection

\[ i^*, y^* \]

Fig. 1. The effect of increased variability in an IS-LM model.

\(^8\)We make no attempt to decide whether risk is optimal. Rules for voting or social choice can raise or lower the risk borne by society, so one meaning of optimal risk defines risk relative to the set of social or political institutions. Procedures that increase the variability of money growth and interest rates at all maturities are sub-optimal for most relevant definitions, however.
of IS\(_0\), LM\(_0\) and \(y^e\) is disturbed by the increase in \(\sigma\). On impact, the increase raises the demand for money; LM shifts to LM\(_1\), raising interest rates to \(i_1\) and reducing the demand for real output. The real balance effect on the demand for output, modifies the quantitative effect, as shown by the broken IS\(_1\) curve in fig. 1. Expected output falls to \(y^e\). The adjustment of the price level assures that, under the hypothesis, IS and LM always intersect on the \(y^e\) line. Real rates of interest are higher; prices and output are lower as a result of the increase in \(\sigma\).\(^9\)

2.2. Measurement of risk

Our measures of risk, or instability, are related to the variability, or instability that people experience when there are real and nominal shocks in the economy. The stochastic process governing the shocks is not constant. People can learn about the process, and they act on the information that they have. But there is uncertainty, reflected by the presence of \(\sigma\) in our equations.

We use two measures of variability. One, the variability of unanticipated velocity growth, reflects shocks affecting both the growth of the demand for money and the growth of output. The other is the variability of unanticipated growth in the stock of money. Three reasons encouraged us to choose these measures of risk.

First, Beveridge and Nelson (1981) show that many aggregate time series for the U.S. appear to have stationary growth rates. Defining stability or variability relative to a series that is perceived as stationary, using data up to the present, has intuitive appeal. The reason is that high variability of the unanticipated growth rate increases the difficulty of detecting promptly any change in the growth rate. The risk of errors in asset allocation increases. Second, we assume throughout that the measures of variability are conditional on currently available information about the state of the economy. Evidence of stationarity of the structure is consistent with this assumption. Further, we assume that the conditional distributions of the variables used to compute measures of variability (for example, the distribution of the unanticipated growth rate of money) are independent of the distributions of the errors in the equations of the model describing levels of the variables. Our measures can satisfy this condition. Third, during much of the period we consider, the Federal Reserve announced targets for the growth rate of money. The variability of the unanticipated growth rate of **

\(^9\)If the higher \(\sigma\) persists, the demand for nominal balances remains unchanged but prices fall and real balances rise. The public now holds more money and less real capital. The one-time reduction in the demand for capital eventually lowers the capital stock. To analyze further the effects on capital and \(y^e\) or compute the relative responses of \(p\) and \(y^e\), we must drop the assumption that \(y^e\) is exogenous to the model. Throughout, the discussion presumes that the coefficient of the real balance effect is less than unity.
money is an appealing measure of the risk that the actual growth rate would differ from the pre-announced growth rate. When there are differences between actual and announced money growth, observers have difficulty distinguishing between large, transitory control errors and unannounced changes in planned money growth. See Cukierman and Meltzer (1982). The larger the variability of unanticipated money growth, the greater is the uncertainty about the relation of planned to observed or actual money growth.

Three sources of risk or variability can be distinguished. One arises from unforseen changes in the growth of nominal values; the risk is that inflation or deflation is misjudged, so allocations between real and financial assets prove to be inappropriate and costly. The second arises from nature, from habits or from trading and social arrangements. Examples are the formation or dissolution of cartels, or changes in regulatory practices, methods of payment and laws. These changes affect the level or growth of output, the expected return from investment in capital and demand for money. A third type of variability arises because monetary policy is used in an attempt to offset real shocks. Such operations, if successful, decrease the variability caused by temporary real shocks, but, if improperly timed or excessive, they can increase variability.\textsuperscript{10}

The sum of the three sources of variability just discussed is the variability of nominal income growth. The quality equation provides a useful way of separating the three components. Let \( m, v \) and \( Y \) denote the first differences of the logarithms of money, monetary velocity and nominal income, where, by definition of velocity

\[
Y = m + v \quad \text{and} \quad \text{var } Y = \text{var } m + \text{var } v + 2 \text{covar}(m, v).
\]

\( \text{var} \) and \( \text{covar} \) denote variances and covariance, respectively. We used time series analysis to decompose the variances and covariance into a systematic or anticipated component and an unanticipated component.\textsuperscript{11} By construction, the anticipated and unanticipated components are statistically independent. Let \( u \) denote the unanticipated component.

\[
\text{var } Y_u = \text{var } m_u + \text{var } v_u + 2 \text{covar}(m_u, v_u).
\]

\textsuperscript{10}Our measure differs from conventional measures of risk, based on the variability of interest rates, asset prices or output prices, discussed in the introduction. In those studies, risk is not related to real and nominal shocks and, usually, anticipated and unanticipated variability is not distinguished.

\textsuperscript{11}We fit univariate time series models to quarterly average values of logarithms of the level of money stock and the level of velocity. The residuals from the model are estimates of innovations. We used the square root of the average sum of squares over four quarters, lagged one period. Variables are scaled to percent per annum. Two procedures were used for \( M \). We relied on a model fitted from 1953–Q3 to 1980–Q1 (peak-to-peak). Then we fit the model each quarter to obtain estimates for 1980–Q2 to 1981–Q4. A similar method was used for velocity. More complete details are available in an appendix obtainable from the authors.
Solely as a matter of convenience, we assume, initially, that covar \((m, v)\) is zero.\(^{12}\)

The two measures of risk separate sources of variability into those attributable to unanticipated changes in money growth and all other unanticipated changes. The former includes variability attributable to unanticipated shifts in monetary policy and slippage or looseness in monetary control procedures relating monetary policy to money. The latter includes all factors that induce unanticipated changes in the growth of the demand for money relative to the growth of output. The latter measure incorporates the much-discussed (unanticipated) shifts in the demand for money, but it does not attribute all change in velocity to shifts in the demand for money.

The October 1979 change in Federal Reserve procedures for controlling money was followed by an increase in the variability of money growth, the variability of velocity growth and the variability of interest rates at all maturities. Instead of trading greater control of money growth for increased variability of interest rates and velocity growth, the change in procedures was followed by increased variability in each of these measures. The Federal Reserve’s review of the first year of operations under the new procedure studies the possible trade-off between the variability of money and interest rates but fails to analyze the concurrent increase in the variability of money growth and interest rates at all maturities. [Board of Governors (1981).]

Table 1 shows some values of the variability of unanticipated money growth \((\sigma_m)\), unanticipated velocity growth \((\sigma_v)\) and the interest rates used in our empirical work. Column (1) is a mixture of within sample estimates through 1980-I and one-step ahead forecasts, beginning 1980-II, based on a univariate time series model estimated from the (NBER) cyclical peak in 1953-III (see footnote 11). Unanticipated growth of velocity, column (2), is computed in the same way as \(\sigma_m\).\(^{13}\) Short- and long-term interest rates are the rates on 90 day prime bankers acceptances and ten year constant maturity government bonds.

The data in table 1 show that \(\sigma_m\), \(\sigma_v\) and the standard deviations of interest rates rose following the change in monetary control procedures. The level of interest rates on short- and long-term securities are between 4 and 5

\(^{12}\)Gould, Miller, Nelson and Upton (1978) show a weak positive relation between \(m\) and \(v\). For the years 1915-1949 and 1950-1972, the reported correlation is less than \(-0.25\). Our computations show a correlation of \(m\) and \(v\) in the neighborhood of \(-0.2\) for the sample periods we used. In a later section, we relax the restriction and introduce the covariance as a variable.

\(^{13}\)To reduce variability, we smoothed the data; \(\sigma_m\) and \(\sigma_v\) are four quarter moving averages, lagged one period. Smoothing reduces the probability of accepting our hypothesis but may more accurately reflect the variability that is relevant for decisions. To reduce the change in monetary variability after 1979-III, we computed an alternate measure using only within sample estimates from 1959-I to 1982-II. Preliminary tests suggested that the main conclusions are similar, so we report only results using \(\sigma_m\).
percentage points higher, on average for periods of comparable length. These data show that the change in Federal Reserve policy procedures did not produce an observable trade-off of lower variability of money growth for higher variability of interest rates. They show, also, that the change in the level and the variability of interest rates appears to differ by maturity. The standard deviation of short-term rates increased less in relative magnitude and more in absolute magnitude than the standard deviation of long-term rates. The mean long-term rate increased less in relative magnitude but approximately the same in absolute magnitude as the mean short-term rate.

The IS-LM model in eqs. (1) to (3) implies that an increase in variability is a sufficient condition for the observed increase in the average level of interest rates after 1979-III. The model cannot distinguish between the effects of \( \sigma_m \) and \( \sigma_v \) or separate the effects of variability on short- and long-term rates. In the following sections, we test for the effects of \( \sigma_m \) and \( \sigma_v \) using a model in which the levels of short and long rates are determined simultaneously.

### Table 1

<table>
<thead>
<tr>
<th>Measures of variability.⁴</th>
<th>( \sigma_m ) (1)</th>
<th>( \sigma_v ) (2)</th>
</tr>
</thead>
</table>

#### Unanticipated money growth and velocity growth

| 9 quarters ending 1979-III | 2.03 | 3.88 |
| 9 quarters beginning 1979-IV | 6.37 | 6.05 |
| | Min. 1.03 | 2.04 |
| After 1979–III | Max. 8.34 | 7.52 |
| | Min. 3.07 | 3.13 |

#### Interest rates

<table>
<thead>
<tr>
<th>9 Quarters Ending 1979-III</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term</td>
<td>8.65</td>
<td>1.91</td>
</tr>
<tr>
<td>Long-term</td>
<td>8.48</td>
<td>0.64</td>
</tr>
<tr>
<td>Beginning 1979-IV</td>
<td>Short-term</td>
<td>14.02</td>
</tr>
<tr>
<td></td>
<td>Long-term</td>
<td>12.54</td>
</tr>
</tbody>
</table>

*The 9 quarter averages of \( \sigma_m \) and \( \sigma_v \) are average values of the four quarter moving averages in periods before and after the change in Federal Reserve operating procedures.*
3. Money, bonds and output

In this section, we extend the IS-LM model by introducing a demand for government securities. People can choose to hold base money, government securities or the fixed stock of real capital. The model remains static, but the demands for financial and real assets now depend on short- and long-term rates, the measures of risk and other variables. We derive the comparative static responses for the extended model.

3.1. The model

The demands for money and output are modified, linear versions of eqs. (1) and (2) that incorporate inflation, interest rates on short- and long-term securities, \( i \) and \( l \), and the two measures of unanticipated variability, \( \sigma_m \) and \( \sigma_v \). The real wealth effect replaces the real balance effect in the demand for output. The modified equations are shown as (4) and (6). Eq. (5) represents the market for (nominal) debt. The relevant stock of government debt is the stock held outside the government and the Federal Reserve Banks. The supply of output, eq. (3), is repeated for convenience,

\[
B = b_0 - b_1 i - b_2 l + b_3 \sigma_m + b_4 \sigma_v + b_5 y + b_6 p - b_7 \pi - \mu + \theta_1, \quad (4)
\]

\[
S = s_0 + s_1(i - \pi) - s_2(l - \pi) + s_3 \sigma_m + s_4 \sigma_v - s_5 y + s_6 p - s_7 \pi - \theta_2, \quad (5)
\]

\[
d = d_0 - d_1(i - \pi) - d_2(l - \pi) + d_3 y + d_4(B + S - p) + g, \quad (6)
\]

\[
y = y^e + \epsilon. \quad (3)
\]

\( B \) and \( S \) denote the logarithms of the stocks of base money and debt; \( i \) and \( l \) are the market rates on short- and long-term debt, respectively; \( \sigma_m \) and \( \sigma_v \) are the measures of the variability of money and velocity growth; \( d, g, y \) and \( p \) are logarithms of aggregate real demand, real government spending, real output and the price level; \( y^e \) is the logarithm of expected output; \( \Pi \) is the anticipated rate of inflation; and \( \epsilon \) and \( \mu \) are shocks to aggregate supply and to money. The sum of the demands for \( B \) and \( S \) is homogenous of first degree in prices and the value of financial wealth.\(^{14}\)

All parameters are positive. Most of the signs reflect standard assumptions or implications of portfolio theory. The negative effect of real income on the demand for debt is an implication of the wealth constraint and the positive effect of \( y \) on the demands for money and capital. The maturity of Federal government securities remains between three and four years during most of the sample period, but a large proportion of the debt has a year or less to

\(^{14}\)In (6) we ignore the difference between the sum of the logs of \( B + S \) and the log of the sum.
maturity. We treat the debt as short term. Our hypothesis is that increased policy instability (\( \sigma_m \)) increases the demands for short-term debt and money and reductions in \( \sigma_m \) reduce the demands for money and short-term securities. We are less certain about the effect of \( \sigma_v \). The Federal Reserve attributes many changes in interest rates to shifts in the demand for money and identifies all shifts in velocity with shifts in the demand for money. Purely transitory changes in the demand for money should have no lasting effect, but increased frequency of transitory changes raises \( \sigma_v \). Strictly as a matter of convenience, we assume that the direction of response to changes in \( \sigma_v \) is similar to the response to \( \sigma_m \). The quantitative effects may differ, however. To close the model, we assume that the risk free real, long-term rate equals the expected return to capital.

The economy is closed. The outstanding stocks of base money and bonds increase or decrease with the financing of budget deficits and surpluses. In principle, the Federal Reserve can control the base directly, but in fact it has not, so there is a random component in the stock of base money. The random component, \( \mu \), is the unanticipated component of the current money stock.\(^1\)

3.2. Comparative statics of the asset market

Eqs. (3) to (6) determine equilibrium values of \( p, y, i, l \) and, under rational expectations, the expected rate of inflation, \( \Pi \), for given or expected values of the monetary and fiscal variables and the variability of money and velocity growth. In this section, we use the general equilibrium solutions for the asset market equations, derived below, to show the effects of changes in the measures of variability, \( \sigma_m \) and \( \sigma_v \), and the financing of the deficit.

We assume that prices and production expected for period \( t \) use all the information available at the end of period \( t-1 \). Shocks to money and production affect aggregate demand and the asset markets. Let \( p^e = E_{t-1} p_t \) be the rational expectation of the (logarithm of the) price level in period \( t \), based on all the information about the economy in eqs. (3) through (6), at the end of period \( t-1 \). Actual \( p \) is \( p^e + \psi \), where \( \psi \) is the error in the equilibrium solution for \( p \) and depends on the shocks \( \mu, e \) and \( \theta \).

Interest rates adjust to the actual and perceived changes that occur during the period. The money market equilibrium relation, \( BB \), and the bond market equilibrium relation, \( SS \), have slopes

\[
\left. \frac{di}{dl} \right|_{BB} = -\frac{b_2}{b_1} < 0 \quad \text{and} \quad \left. \frac{di}{dl} \right|_{SS} = \frac{s_2}{s_1} > 0.
\]

\(^1\)If the Federal Reserve directly controls the base, unanticipated increases or reductions in the budget deficit raise or lower the stock of debt. When the Federal Reserve controls interest rates or unborrowed reserves, in principle there is an error term, similar to \( \mu \), in the stock \( S \). Without loss, we ignore this error.
The positions of the two curves depend on expected real income, $y^e$, the shocks $\theta$, $\varepsilon$ and $\mu$, and the values of $\sigma_m$, $\sigma_v$, $p^e$ and $\Pi$. The $BB$ and $SS$ relations are shown in fig. 2. The intersection of the two curves determines the values of $i$ and $l$ at which people willingly hold the outstanding nominal stocks of base money and bonds; for given $\Pi$, the curves also determine values of $i-\Pi$ and $l-\Pi$ at which the stocks of real capital and debt are willingly held.

The money market equilibrium relation, $BB$, is negatively sloped. Reductions in both short- and long-term interest rates increase the quantity of money demanded, so a decline in one rate must be offset by a rise in the other to keep the money market in equilibrium. The short-term rate, $i$, is taken as the own rate on government bonds; a rise in $i$ increases the quantity of bonds demanded. The bond market equilibrium relation, $SS$, is positively sloped. An increase in long-term rates induces substitution away from bonds; short-term rates must rise to maintain the bond market equilibrium at given expectations and risk. The broken 45° line in fig. 2 shows positions at which short- and long-term rates are equal. Along the broken line, the term structure showing market interest rates by term to maturity is flat.\(^{16}\)

\(^{16}\)If there is a constant, positive liquidity premium, the term structure line does not go through the origin but has an intercept at a positive value on the $i$-axis. The line shows positions at which the difference between short- and long-term rates is constant.
The asset markets are in equilibrium at the intersection of $B_0B_0$ and $S_0S_0$. At prevailing short- and long-term rates, the desired allocation of portfolios between money, bonds and capital is the same as the outstanding asset stocks. Short- and long-term market rates are equal at the prevailing level. If the anticipated rate of inflation is constant over the maturities represented by $i$ and $l$, 'real' short- and long-term rates are equal also. The intersection along the broken line seems a useful starting point for the discussion of disturbances, although other positions of equilibrium in asset markets, along positively and negatively sloped yield curves, can and do occur.

Suppose the variability of unanticipated money growth increases. Specifically, assume that a change in monetary policy procedures increases the variability of unanticipated money growth, $\sigma_m$. The increase in $\sigma_m$ induces changes in desired portfolios. Under our hypothesis, increased instability reduces the demand for (claims to) real capital, and increases the demands for money and debt. The increase in the demand for money is shown by the shift in the money market equilibrium curve to the position shown as $B_1B_1$. This shift increases interest rates on short- and long-term bonds. The increase in the demand for (short-term) debt to $S_1S_1$ raises rates on long-term debt but lowers the (own) rate on short-term debt.

In the IS-LM model above, government debt is a perfect substitute for real capital. There is only one interest rate. An increase in $\sigma_m$ raises the rate of interest, if it is included as an argument in the demand for money. The ambiguity about the effect of $\sigma_m$ on short-term rates arises here because debt and real capital are not perfect substitutes. The increase in risk has two effects on the short-term rate. The demand for (short-term) debt increases, lowering $i$, and the demand for money increases, raising $i$. Analytically the positive response of $i$ to $\sigma_m$ depends on $s_2 > b_2$; the response of debt to long-term rates must exceed the response of base money. Here, we assume that this condition holds, and we test the hypothesis in the following section.

The qualitative responses of $i$ and $l$ to changes in the variability of unanticipated velocity growth, $\sigma_v$, are assumed to be the same as the responses to $\sigma_m$; the quantitative responses depend on the size of $b_3$ and $s_3$ relative to $b_4$ and $s_4$. If $b_4$ and $s_4$ are close to zero, $i$ and $l$ are unaffected by $\sigma_v$. For positive values of $b_4$ and $s_4$ and $s_2 > b_2$, and increase in $\sigma_v$ raises long- and short-term rates. If the variability of velocity growth is dominated by unanticipated shifts in the demand for money, as the Federal Reserve often claims, an increase in the frequency of such shifts raises rates, and a reduction lowers rates. The variability of unanticipated velocity growth may change for other reasons, most notably, changes in the frequency of shifts or

---

17 The full condition is $s_2b_3 > b_3s_3$. A decline in short rates requires $b_3/s_3 > b_4/s_4$; a comparatively large response of money ($b_3$) to long-term rates or a negligible effect on the precautionary demand for money ($b_4$) relative to the demand for debt is sufficient to produce a negative response of $i$ to $\sigma_m$. 


shocks affecting the measured growth of aggregate supply. Such changes have effects on interest rates similar to the effect of shifts in the demand for money.

A peculiar feature of recent interest rates was the persistence of a relatively flat yield curve for market rates of interest during the 1981–82 recession. Changes in short- and long-term rates were often in the same direction and similar in magnitude. Such changes are consistent with a flat yield curve and shifting positions of asset market equilibrium along that yield curve, as shown in fig. 2.

Our hypothesis does not imply that changes in $\sigma_m$ or $\sigma_x$ produce equilibrium along a flat yield curve. Even if $s_2 > b_2$, changes in perceived risk can change $i$ and $l$ by unequal amounts. The critical condition required to explain the persistence of a relatively flat yield curve at different rates of interest as a response to changes in risk is $s_2 > s_1$. This can be seen in figure 2. If $s_2 > s_1$, the slope of $SS$,

$$\frac{di}{dl} \bigg|_{SS} = \frac{s_2}{s_1},$$

is greater than unity. Increases in risk that shift both $BB$ and $SS$ to the right and reductions in risk that shift $BB$ and $SS$ to the left can intersect along the 45° line. If $s_2 = s_1$, the $SS$ curve and the 45° line are parallel (or coincident). If long- and short-term rates were equal before a change in risk, they cannot be equal after the change. If $s_2 < s_1$, the $SS$ curve is relatively flat; changes in $\sigma_m$ or $\sigma_x$ induce relatively large changes in $l$ and relatively small positive (or negative) changes in $i$.

Some additional, comparative statics results are shown in table 2. Increases in the monetary base lower $l$ and $i$, and increases in government debt raise $i$ but lower $l$. Contrary to many statements about the effects of deficits and deficit finance on interest rates, our hypothesis implies that increases in debt

---

18Quarterly values for prime bankers acceptances, ($i$), and AAA corporate bonds, ($l$), reported by the Federal Reserve Bank of St. Louis, are:

<table>
<thead>
<tr>
<th>Date</th>
<th>$i$</th>
<th>$l$</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/2/81</td>
<td>15.83</td>
<td>15.85</td>
<td>0.02</td>
</tr>
<tr>
<td>1/1/82</td>
<td>12.67</td>
<td>14.50</td>
<td>1.83</td>
</tr>
<tr>
<td>4/1/82</td>
<td>14.13</td>
<td>14.55</td>
<td>0.42</td>
</tr>
<tr>
<td>7/2/82</td>
<td>14.73</td>
<td>15.07</td>
<td>0.24</td>
</tr>
</tbody>
</table>

The relatively flat yield curve shifted to a positive slope in the winter of 1982 but returned in the spring and remained until mid-summer. In our empirical work, we use end of quarter values, not the average values shown here.
Table 2  
Comparative statics responses for the asset markets. 

<table>
<thead>
<tr>
<th>$B$</th>
<th>$-s_2&lt;0$</th>
<th>$-s_2&lt;0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S$</td>
<td>$b_2&gt;0$</td>
<td>$-b_1&lt;0$</td>
</tr>
<tr>
<td>$s_m$</td>
<td>$s_2b_2-b_2s_3&gt;0^b$</td>
<td>$s_1b_3+b_1s_3&gt;0$</td>
</tr>
<tr>
<td>$s_v$</td>
<td>$s_2b_2-b_2s_4&gt;0^b$</td>
<td>$s_1b_4+b_1s_4&gt;0$</td>
</tr>
<tr>
<td>$s^*$</td>
<td>$s_2b_2+b_2s_3&gt;0$</td>
<td>$s_1b_5-b_1s_5$</td>
</tr>
</tbody>
</table>

*Each of the responses in the table is divided by the determinant, $b_1s_2+b_2s_1$. 

The economic rationale is more informative. The negative effect of debt issues on long-term rates reflects the maturity of the debt and the substitution we have assumed. Long-term securities (in real terms) are a perfect substitute for claims to real capital in our hypothesis, but short-term debt is not. An increase in debt, as used in the model, means that short-term debt is issued to finance the increased deficit. The increase in short-term debt raises short-term interest rates, as shown in table 2, inducing substitution of short-term debt for money and real capital in portfolios. To maintain equilibrium in the market for real capital, the price of real capital rises and the (real) interest rate on real capital falls. In the model, the (real) rate on real capital is equal to $l - \Pi$ so, given expectations, $l$ falls as $S$ increases.

The model provides for the simultaneous determination of a term structure of rates. Differences in the responses of $i$ and $l$ to the predetermined or policy variables of the model have implications for cyclical changes in the term structure. Short rates typically fall relative to long rates in recession and rise relative to long rates in expansion. The observed changes in rates during recessions and expansions are consistent with possible differences in the effects of expected income, $y^*$, on $i$ and $l$, shown in table 2. Cyclical changes in the slope of the yield curve are also consistent with people's perceptions of the transitory nature of many changes in $B$, $S$, and $y^*$.

4. Solution and estimation

Solving eqs. (4) and (5) for $i$ and $l$, substituting the solutions in eq. (6) and using the equilibrium condition for the output market, $y=d$, we have (7)

$$y = d_0 - d_1(l - \Pi) + d_2l + (d_1 + d_2)\Pi + d_3y + d_4(B + S + p)$$

$$+ g - d_4\mu + d_4\beta.$$  

(7)
The parentheses contain the variables of the money and bond equations — $B, S, \sigma_m, \sigma_v, y, p^r, \text{ and } \Pi$. The coefficients of the shocks depend on some parameters of the asset market equations. Solving (7) for $p$ gives

$$p = \sum \gamma_j x_j + \gamma_\pi \pi + \gamma_\mu \mu + \gamma_\theta \theta,$$

where $x_j$ is an element of the vector $[B, S, \sigma_m, \sigma_v, y, \mathbb{E}]$ and $\Pi = \mathbb{E} \Pi_{t+1} - p$. The $\gamma_j$ are the reduced-form coefficients obtained from the solution of $i, l$ and $p$ in terms of the $x$ vector and $\Pi$. Using the expression $H = \sum \gamma_j x_j$, rewrite (8) as

$$p = H + \gamma_\mu (\mathbb{E} \Pi_{t+1} - p) + \gamma_\mu \mu + \gamma_\theta \theta = (1 - \lambda) H + \lambda \mathbb{E} \Pi_{t+1} + w,$$

where $\lambda = \gamma_\Pi/(1 + \gamma_\Pi)$, $w = (\gamma_\mu \mu + \gamma_\theta \theta)/(1 + \gamma_\Pi)$, and $\gamma_\Pi$ can be shown to be positive. Repeated substitution for future prices in (9) results in the familiar rational expectations price equation in which current price depends on current expectations of the future path of the elements in $H$, as shown in (10),

$$p = (1 - \lambda) \mathbb{E} \sum_{k=0}^\infty \lambda^k H_{t+k} + w.$$

By advancing (10) one period and then subtracting (10) and taking expectations, we obtain an equation for expected inflation in period $t+1$,

$$\pi_{t+1} = (1 - \lambda)[(\mathbb{E} \Pi_{t+1} - \mathbb{E} H) + \lambda (\mathbb{E} \Pi_{t+2} - \mathbb{E} \Pi_{t+1}) \lambda^2 (\mathbb{E} \Pi_{t+3} - \mathbb{E} \Pi_{t+2}) + \cdots].$$

(11)

Eq. (11) shows that expected inflation depends on current expectations of the future paths of the exogenous variables. We ignore revisions of data and assume that $\mathbb{E} H = H$.

4.1. Estimation procedure

Eq. (11) is the rational expectation of next period's inflation conditional on all available information specified by the static model. To estimate (11), we require information about the elements of $H$. Our approach uses what is known, or can be learned, from univariate, time series models for each of the elements of the vector $H$. We obtain two types of information. The first is knowledge of the time-series structure of a particular series. This allows us to replace the infinite forward progression with the (estimated) finite distributed lag structure. The distributed lag structures generally involve innovations in a given $x_j$ and, at times, actual lagged values of $x_j$ itself. The second type of information taken from the univariate models is the series of estimated
systematic values and innovations. The static nature of the model implies that terms like $H_{t+2}$, $H_{t+3}$, etc. do not effect the current value of $H$, but each period the estimate of $H$ is revised using any new information about $H$ that alters the next period forecast of $H$. An example helps to clarify the procedure.\footnote{Additional details are available from the authors on request.}

Time-series analysis of the log of real GNP from 1953-III through 1983-II suggests that $y$ is adequately represented by the first-order, moving average model:

$$y_{t+1} = y_t + a_{t+1} - \theta a_t, \quad \theta = -0.34 \quad (t\text{-stat.} = 3.88), \quad Q(7\text{df.}) = 6.32.$$

Recalling that $H = \sum y_j x_j$ the $y$-element of (11) is given by

$$J_y = \sum_{k=0}^{\infty} \delta^k (Ey_{t+k+1} - Ey_{t+k}).$$

Using the empirical form of $y$ estimated above, we represent this infinite series with

$$J_{y,t+1} = -\gamma_{1} a_{t}.$$ 

The $y$-component of (11) depends on the innovations of the $y$-series. At time $t$, we know $a_t$, so we use this value to forecast $y_{t+1}$ in the equation for $H$. Table 3 summarizes the results for each component of $H$ (the $x$-vector) in the equation for $H$. The footnotes to the table explain the notation.

We estimated eq. (11) for two periods beginning 1969-III, using the lag structures and specifications obtained from the time series models. The first period ends with the change in monetary procedures; the second ends in first quarter 1982. The Durbin–Watson statistics permit us to assume that the errors in the equations for the actual rate of inflation, $w_{t+1} - w$, follow a first-order Markov process. The models account for 60 to 70 percent of the variance of reported inflation after adjusting for the (more than 20) degrees of freedom used in the computations.\footnote{Before adjustment, the $R^2$'s are 0.81 and 0.86. These and other estimates for the inflation equations and for the equations in table 3 are available from the authors.} To supplement the reduced form inflation equation, we estimated a univariate time-series model for the period beginning and ending with cyclical peaks, 1953-III — 1980-I. The time series model has a standard error of 1.52, approximately 12% above the error obtained using our static version of rational expectations.
Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Time-series model</th>
<th>Structure in inflation equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B$</td>
<td>(0, 2, 2)</td>
<td>$\Delta B_t; a_0, a_{-1}$</td>
</tr>
<tr>
<td>$S$</td>
<td>(0, 1, 2)(0, 1, 1)</td>
<td>$\Delta S_t; \cdots, \Delta S_{t-3}$</td>
</tr>
<tr>
<td>$\sigma_m$</td>
<td>(0, 1, 4)</td>
<td>$a_0, \cdots, a_{-5}$</td>
</tr>
<tr>
<td>$\sigma_v$</td>
<td>(0, 1, 6)(0, 0, 1)</td>
<td>$a_1, \cdots, a_{-9}$</td>
</tr>
</tbody>
</table>

*a $(V_1, V_2, V_3)(S V_1, S V_2, S V_3)$q is conventional notation, where $V_1, V_2, V_3$ refer, respectively, to the number of autoregressive parameters, the degree of differencing of the primary series, and the number of moving average parameters. The second set is identical but refers to seasonal counterparts; q is the period of seasonality.

*b $\theta$ refers to the errors or 'innovations' of the respective time-series model.

*c $\sigma_m = \theta_2 = 0, (\theta_1, \theta_4) \neq 0$, where the $\theta_i$ are the coefficients of the moving average. As elsewhere, $\sigma_m$ is itself a four quarter moving average.

d $\theta_1 = \cdots = \theta_5 = 0, \theta_6 \neq 0$. $\sigma_v$ is a four quarter moving average.

4.2. Reduced form estimates for interest rates and tests of the hypothesis

This section presents two sets of estimates of the reduced form equations for long- and short-term interest rates derived from the model. The first set, using data for 1969-IV through 1979-III, is a test of our hypothesis that increases in the variability of unanticipated money growth ($\sigma_m$) raise interest rates at all maturities and reductions in $\sigma_m$ lower rates. We also test a version of the Federal Reserve hypothesis that increases in $\sigma_m$ raise, and reductions lower, $i$ and $l$. These tests use data only for the period before the 1979 change in procedure to avoid bias. The change in Federal Reserve control procedures was followed by increases in $\sigma_m, \sigma_v, i$ and $l$ as shown in table 1 earlier; including these correlated changes in the test period can lead to acceptance of a false hypothesis.

The second set of estimates includes data for the nine quarters following the change in monetary control procedure. The use of data for the extended period tests whether the estimated effects of $\sigma_m$ and $\sigma_v$ changed following the change in procedures.

Table 4 shows estimates of the $i$ and $l$ equations using the static rational expectations values of $p^e$ and $\Pi$, the values of $B$ and $S$ measured at the beginning of the quarter and values of $i$ and $l$ for the last month of the

21We use $p^e$ as an instrument in place of $\pi$, where $p^e = p_{t-1} + \pi/400$, and $\pi$ is the fitted value from the corresponding model of inflation.
quarter. The data support our hypothesis that long- and short-term interest rates rise and fall with $\sigma_m$. Supply shocks affect short and long rates by changing $\varepsilon$, and past supply shocks by changing $\gamma'$. Unexpected shifts in the demand for money affect interest rates through $\theta_1$. The data give little support to the emphasis the Federal Reserve places on variability of the demand for money or to the effects of unanticipated shocks to output through $\sigma_v$. In our test, we do not find a reliable effect of the variability of velocity growth similar to the effect of $\sigma_m$.

Our hypothesis allows deficit finance to change interest rates by changing $B$ and $S$. We find relatively strong, negative effects of the base for both short- and long-term rates. The coefficients of $B_{-1}$ are proportional to $-s_2$ and $-s_1$, respectively, as shown in table 2, so they suggest relatively strong responses of the demand for debt to interest rates. The ratio of the two, $s_2/s_1$ is the slope of the SS curve in fig. 2. The estimate of this slope from table 4 is 2.7 (136/50), considerably above unity.

### Table 4

<table>
<thead>
<tr>
<th></th>
<th>90 day</th>
<th>10 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>14.75</td>
<td>80.62</td>
</tr>
<tr>
<td>$B_{-1}$</td>
<td>-135.87</td>
<td>-49.67</td>
</tr>
<tr>
<td>$S_{-1}$</td>
<td>-6.86</td>
<td>-1.41</td>
</tr>
<tr>
<td>$\sigma_m$</td>
<td>0.75</td>
<td>0.30</td>
</tr>
<tr>
<td>$\sigma_v$</td>
<td>0.13</td>
<td>-0.06</td>
</tr>
<tr>
<td>$\gamma'$</td>
<td>88.04</td>
<td>21.39</td>
</tr>
<tr>
<td>$\pi$</td>
<td>0.70</td>
<td>0.17</td>
</tr>
<tr>
<td>$\pi'$</td>
<td>127.49</td>
<td>53.00</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.82</td>
<td>0.82</td>
</tr>
<tr>
<td>$DW$</td>
<td>2.57</td>
<td>1.84</td>
</tr>
<tr>
<td>$SEE$</td>
<td>0.92</td>
<td>0.39</td>
</tr>
</tbody>
</table>

The effects of debt finance on both rates is relatively small and, for the short rate, the sign is opposite to the sign implied by our hypothesis. There are several possible explanations. The maturity of the public debt may be too long for our purposes. The neglect of off-budget borrowing, guarantees and commitments may bias the coefficients. Or, as emphasized by Barro (1974), government debt may have no significant effect on wealth or intertemporal allocation.

Most of the other coefficients require few comments. There is no implication in our analysis that the partial effect of $II$ on $i$ or $l$ is near unity. The equations of the model show that the impact effects of $II$ on $i$ and $l$

---

22There are no published data until the mid-seventies on the maturity composition of the debt held by the public.
depend on the relative size of \( s_1, s_2 \) and \( s_7 \). One-time increases in \( \Pi \), measured by our static procedure, can have different effects on \( i \) and \( I \). We would expect sustained changes to have similar effects, but these are not caught in our static model.

Table 5 reports estimation for the extended period using two measures of \( \Pi \) and \( p^e \). The rational expectations estimates use revised estimates of \( \Pi \) and \( p^e \) based on data for a longer sample ending in 1981-IV. The ARIMA estimates of \( \Pi \) and \( p^e \) are taken from a univariate time series model.

Table 5

<table>
<thead>
<tr>
<th></th>
<th>90 day rate</th>
<th>10 year rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(A)</td>
<td>(B)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.76 (-0.04)</td>
<td>250.33 (3.59)</td>
</tr>
<tr>
<td>( B_{-1} )</td>
<td>-89.62 (-4.11)</td>
<td>-43.17 (1.79)</td>
</tr>
<tr>
<td>( S_{-1} )</td>
<td>-3.04 (0.68)</td>
<td>5.12 (0.79)</td>
</tr>
<tr>
<td>( \sigma_w )</td>
<td>0.73 (3.82)</td>
<td>0.86 (3.89)</td>
</tr>
<tr>
<td>( \sigma_e )</td>
<td>0.17 (0.91)</td>
<td>0.49 (2.52)</td>
</tr>
<tr>
<td>( p^r )</td>
<td>57.67 (3.83)</td>
<td>57.71 (3.27)</td>
</tr>
<tr>
<td>( \pi )</td>
<td>0.92 (5.30)</td>
<td>0.99 (3.88)</td>
</tr>
<tr>
<td>( p^e )</td>
<td>80.95 (3.74)</td>
<td>15.40 (0.60)</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.84 (0.80)</td>
<td>0.80 (0.80)</td>
</tr>
<tr>
<td>( DW )</td>
<td>2.25 (2.07)</td>
<td>2.53* (2.12)</td>
</tr>
<tr>
<td>( SEE )</td>
<td>1.43 (1.62)</td>
<td>0.57 (0.65)</td>
</tr>
</tbody>
</table>

*Column (A) uses \( p^e \) and \( \pi \) derived from model; column (B) uses \( p^r \) and \( \pi \) from univariate time series model.

Comparison of tables 4 and 5 shows that the effect of \( \sigma_w \) on \( i \) and \( I \) is unchanged when the nine additional quarters are added. The estimates for short and long rates in table 5, using both measures of expected prices and inflation, are within one standard deviation of the coefficients in table 4. This suggests that the effect of increased variability of money growth on interest rates is proportional to the increase in variability shown in table 1 above.
Using the coefficients in table 4, the measures of $\sigma_m$ in table 1 imply that on average long rates increased by 1.3 and short rates by 3.3 percentage points in the nine quarters following the change in Federal Reserve procedures.

The larger effect of $\sigma_m$ on $i$ than on $l$ is consistent with our hypothesis provided $s_2$ is large relative to $b_2$ and $s_1$. Our estimates of $s_2/s_1$ from table 5, based on the ratio of coefficients of the base, $B$, in the two sets of $i$ and $l$ equations, are 1.82 and 1.40. These are somewhat lower than the estimate for the earlier period (2.7); the response of short-rates to the base in the extended sample appears to have been lower than in the period before 1979-III. In all cases, however, the ratio $s_2/s_1$, the slope of $SS$, is substantially above unity. Failure to find a significant effect of $S$ on $i$ leaves some doubt about the precise value of $b_2$, but comparison of the effects of $B$ and $S$ on $i$ in tables 4 or 5 leave little doubt that $s_2$ is considerably larger than $b_2$. The smallest estimate of $s_2/b_2$, from column (B) of table 5, is approximately 8. We return to this issue below.

Comparison of tables 4 and 5 shows that the effect of $\sigma_v$ on $i$ and $l$ remains negligible. Again, there is little evidence for this version of the Federal Reserve’s hypothesis. The increase in $\sigma_v$ following the 1979 change in control procedures, shown in table 1, appears to have had much less effect on interest rates than the increase in $\sigma_m$.

5. Inferences and implications

The estimated effects of unanticipated monetary variability leave little doubt that increased monetary variability raised the average level of short- and long-term rates following the October 1979 change in Federal Reserve procedures. Increased variability of interest rates at all maturities can be explained by the change in control procedures also, if the variability of $\sigma_m$, $\sigma(\sigma_m)$, increased with the mean value of $\sigma_m$. The data in table 1, showing the range of values of $\sigma_m$, suggest that the variability of $\sigma_m$ increased. Comparison of the standard deviation of quarterly values of $\sigma_m$ for the nine quarters before and after the October 1979 change supports this inference. The standard deviation of $\sigma_m$, $\sigma(\sigma_m)$, increased in proportion to the increase in $\sigma_m$, rising from 2.10 to 6.82. The standard deviation of long-term rates increased in about the same proportion, and the standard deviation of short-term rates increased less than proportionally, as shown in table 1. These data suggest that the increase in $\sigma(\sigma_m)$ is sufficient to account for much of the observed increase in $\sigma_l$ and $\sigma_t$ in recent years.

Increased variability of interest rates after 1979-III is consistent with the hypothesis that the change in control procedures pushed the economy to a less stable position. Increased variability of unanticipated money growth raised short- and long-term rates, by 3.3% and 1.3% on average, according to our estimates, and raised the variability of interest rates, so interest rates, the
variability of interest rates and the variability of money growth all increased. Our hypothesis implies that the increased risk induced increases in the demand for money and the demand for short-term government debt.

The univariate time series model for money provides additional, rather striking evidence of the effect of the change in control procedures. By third quarter 1980, sequential estimates for the period beginning 1969-IV — used to form the out-of-sample, one period ahead forecasts of $M_1$ — shifted from an autoregressive process and became a random walk. The equation remained a random walk for the rest of the period considered.

Our finding that log $M_1$ shifted from an autoregressive process to a random walk suggests that the past history of money contained no information useful for forecasting contemporaneous or future values of $M$ after 1980-III. Each shift in quarterly money growth appears to have been treated as a permanent shift, so expectations of the trend moved up and down with the actual series. The random walk shows shifting confidence in the Federal Reserve's ability or intention to control money growth and achieve pre-announced targets. Uncertainty about Federal Reserve policy appears to be a principal reason for the increased variability of interest rates, the stock of money, the demand for money and aggregate output.

The model is over-identified, and the coefficients of $S$ are not significant in the reduced form equations for $i$ and $l$. We cannot estimate the structural equations to infer the effects of $\sigma_m$, $\gamma$, and other variables on the demands for base money and securities.

An alternative procedure provides some of the desired estimates. The demands for financial assets are homogeneous of first degree in $p$. Holding $p^{t+1}_e$ constant, to eliminate an effect on future prices, we have

\[ \frac{\partial \pi}{\partial B} + \frac{\partial \pi}{\partial S} = -\frac{\partial \pi}{\partial p^e} - \frac{\partial \pi}{\partial \pi} \bigg|_{p^{t+1}_e} \]  

and similarly for $l$. The coefficients of $B$, $p^e$ and $\pi$ are reasonably well estimated, so we use these values with eq. (12) to compute $\frac{\partial \pi}{\partial S}$ (and similarly for $\frac{\partial \pi}{\partial S}$). Further, table 2 shows that the coefficients of $B$ in the $i$ and $l$ equations are estimates of $-s_2/A$ and $-s_1/A$ while the coefficients of $S$ are $b_2/A$ and $b_3/A$. By imposing the homogeneity constraint, we can compute the latter. For example, using the coefficients from table 4 for $\frac{\partial \pi}{\partial B}$ and $\frac{\partial \pi}{\partial p^e}$, and $\frac{\partial \pi}{\partial \pi}$, we have:

\[ -135.87 + 127.49 - 0.70 = -9.08 = -b_2/A, \]  

and

\[ \frac{\partial \pi}{\partial B} \bigg|_{p^{t+1}_e} = -s_2/A, \quad \text{and} \quad \frac{\partial \pi}{\partial S} \bigg|_{p^{t+1}_e} = b_2/A, \]  

for $B$, $p^e$ and $\pi$, respectively.
so \( \frac{b_2}{A} = 9.08 \). The same computation using the values in table 5 implies \( \frac{b_2}{A} = 9.57 \). The computed values are shown at the bottom of table 6. Only \( s_2/A \) shows a change between sample periods.

Next, we compute the values of \( b_5, s_5, b_3 \) and \( s_3 \) to find the effects of \( \sigma_m \) and \( y^e \) on the demands for base money and bonds, using the coefficients of \( y^e \) and \( \sigma_m \) reported in table 4. Then, we repeat the computations using the values in table 5 to check consistency.

An example illustrates the procedure. In table 2, we find

\[
\frac{\partial l}{\partial y^e} = (s_2/A)b_5 + (b_2/A)s_5, \quad \text{and} \quad (13a)
\]

\[
\frac{\partial l}{\partial y^e} = (s_1/A)b_5 - (b_1/A)s_5. \quad (13b)
\]

Using the coefficients of \( y^e \) in table 4 with the values of \( s_j/A \) and \( b_j/A \) \((j=1,2)\) in table 6, we can solve (13a) and (13b) for \( b_5 \) and \( s_5 \). The estimates are shown in table 6.

<table>
<thead>
<tr>
<th>Variable or slope</th>
<th>Coefficient</th>
<th>using table 4</th>
<th>using table 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y^e )</td>
<td>( b_5 )</td>
<td>0.54</td>
<td>0.49</td>
</tr>
<tr>
<td>( s_5 )</td>
<td>1.66</td>
<td>1.43</td>
<td></td>
</tr>
<tr>
<td>( \sigma_m )</td>
<td>( b_3 )</td>
<td>0.0062</td>
<td>0.0078</td>
</tr>
<tr>
<td>( s_3 )</td>
<td>0.0041</td>
<td>-0.0034</td>
<td></td>
</tr>
<tr>
<td>( BB )</td>
<td>(-b_2/b_1)</td>
<td>-2.87</td>
<td>-2.57</td>
</tr>
<tr>
<td>( SS )</td>
<td>( s_2/s_1 )</td>
<td>2.74</td>
<td>1.82</td>
</tr>
<tr>
<td>Constraint</td>
<td>( s_2/s_2 &gt; 1 )</td>
<td>15.00</td>
<td>9.36</td>
</tr>
<tr>
<td>Based on:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( b_1/A )</td>
<td>3.16</td>
<td>3.72</td>
<td></td>
</tr>
<tr>
<td>( b_2/A )</td>
<td>9.08</td>
<td>9.57</td>
<td></td>
</tr>
<tr>
<td>( s_2/A )</td>
<td>49.67</td>
<td>49.15</td>
<td></td>
</tr>
<tr>
<td>( s_3/A )</td>
<td>135.87</td>
<td>89.62</td>
<td></td>
</tr>
</tbody>
</table>

The two sets of values for \( b_5 \) and \( s_5 \) are similar. Both imply a very strong effect of expected income on the demand for securities and a much smaller effect on the demand for base money. Increases in \( y^e \) reduce the demand for bonds by much more than they increase the demand for (base) money. The reduction in the demand for bonds raises short-term rates but lowers long-term rates. The increase in the demand for money raises both rates. The computations in tables 4 and 5 show that both short and long rates rise.

\(^{24}\)In passing, we note that the \( l \)-equations imply that the coefficient of \( S, b_2/A > 0 \), while the \( l \)-equations imply that the coefficient of \( S, b_1/A < 0 \). (See table 2.) These are the signs implied by the hypothesis.
fall with \( y^* \), but short rates change much more than long rates. This is consistent with the observed cyclical changes in short- and long-term rates.

The estimates for \( b_3 \) from the two sample periods in table 6 are, again, similar. The estimates of \( s_3 \) are not. The computations suggest that after 1979-III, \( s_3 \) turned negative; increases in the variability of unanticipated money growth reduced the demand for short-term debt. A negative value of \( s_3 \) reinforces the effect of \( \partial l / \partial \sigma_m \) on short-term rates and reduces the effect on long-term rates, contrary to our hypothesis. The change in \( s_3 \) was not large enough to change the sign of \( \partial l / \partial \sigma_m \), however. In fact, \( \partial l / \partial \sigma_m \) is larger in table 5 than in table 4 because the computed values of \( b_3 \) rose more than \( s_3 \) fell. Nevertheless, the small negative value of \( s_3 \) contradicts our hypothesis about substitution. In the longer sample, increases in \( \sigma_m \) appear to have induced substitution into money, as we assume, but induced substitution out of both short- and long-term securities.

The computed values of \( b_3 \) in table 6 support the conjectures of Keynes, and Friedman and Schwartz. The demand for money increased with the instability of money growth. To avoid the main effects of the credit control program in 1980, we use the change in value of \( \sigma_m \) from late 1978 to late 1981, approximately 6, to illustrate the effect of \( \sigma_m \) on the demand for (base) money. At the lesser value of \( b_3 \) in table 6, the increase in \( \sigma_m \) raised money holdings by 3 to 4%. At the larger value of \( \sigma_m \), the increase is nearly 5%. These estimates seem high but, if supported by other data, they account for most of the observed decline in measured velocity and part of the decline in the measured rate of inflation during recent years.

Computations of \( b_4 \) and \( s_4 \) are not included in table 6. The coefficients of \( \sigma_v \) in tables 4 and 5 reject the hypothesis that \( \sigma_v \) affects interest rates. Our computations of \( b_4 \) and \( s_4 \) suggest that \( b_4 \) is close to zero and \( s_4 \) is negative, but not much confidence can be placed in these estimates since the coefficients of \( \sigma_v \) in tables 4 and 5 are not significantly different from zero.

The differences in the effect of \( \sigma_m \) and \( \sigma_v \) on interest rates during the sample periods suggest that the source of variability mattered. Unstable monetary policies, reflected by a large \( \sigma_m \), were not treated as transitory events that average out during the quarter. Wealth owners rearranged portfolios increasing desired holdings of money and short-term debt, thereby slowing the measured rate of price change and raising interest rates. Increased \( \sigma_v \) appears to have had, at most, a transitory effect. Any effect on the demands for money and other assets occurred within the quarter and did not persist.

To obtain signs for the comparative statics responses in table 2, we assumed \( s_3 / b_2 > 1 \). Table 6 shows two estimates. Both are well above unity, so the constraint appears to be met. Changes in long-term rates have a much larger effect on the demand for debt than on the demand for money. Given \( \pi \), an increase in long-term rates reduces demands for debt and money and
increases the demand for claims to real capital. The dominant substitution appears to be from debt to real capital; the effect on the demand money is from 7 to 10% of the effect on debt, according to our estimates.

Table 6 also reports estimates of the slopes of the SS and BB curves of fig. 2. These slopes are inconsistent with the claim that debt issues, to finance deficits, raise long-term rates. Debt issues shift the SS curve along BB, raising short rates and lowering long rates. The relatively steep slope of BB implies that the principal effect is on short rates. A 10 to 15% increase in debt, as in recent years, raises short-term rates from 1 to 1 1/2 percentage points and lowers long-term rates by, at most, 4%. Changes in money have a much more potent impact effect on short- and long-term rates. A change in the base shifts BB along the positively sloped SS; increases in B lower short and long rates and reductions in B raise rates. Ceteris paribus, a given decline in the base increases short rates by 2 to 3 times the rise in long-term rates. When \( p^e \) adjusts, the effects of \( B \) and \( S \) on real rates of interest are reversed. These findings differ markedly from those reported in recent studies of the term structure by Mishkin (1981) and Shiller (1979).

The separation of money, debt and capital suggests a mechanism producing cyclical changes in interest rates and asset demands. The interest responses on the securities market, shown in our tables 4 and 5, are a large multiple of the response estimated for the base money market. In the money, debt and capital model, the financing of budget deficits and expectations shifts both the BB and SS curves and, thus, produce the relatively large cyclical responses in long and short rates characteristic of business cycles. The effects of \( B \), \( y^e \) and \( p^e \) are typically larger in the estimated short-rate than in the long-rate equations. This is consistent with the observed cyclical pattern.

A negative relation of anticipated inflation and anticipated real rates of return, following the Mundell (1963) hypothesis, implies that anticipated inflation lowers the real rate of interest and increases the stock of capital. Evidence for this hypothesis is mixed. A recent paper by Fama and Gibbons (1982) introduces a different rationale than Mundell's but claims to find a significant negative relation between anticipated inflation and anticipated real returns on Treasury bills.

Our hypothesis provides two measures of short- and long-term anticipated 'real' rates. The first is computed by subtracting \( c_{17}\pi \) or \( c_{27}\pi \) from the expected value of the interest rates, \( Ei \) and \( EL \), where \( c_{17} \) and \( c_{27} \) are the coefficients of \( \pi \) in the reduced form equations and \( E \) is the expected value.
operator. Let $r_i$ and $r_l$ denote these measures of the real rate. The second measure of the real rate adjusts for risk. We compute

$$r_{ia} = E_i - c_1\pi - c_{13}\sigma_m - c_{14}\sigma_y$$

and similarly for $r_{la}$. Table 7 shows the correlations between these measures of the 'real' rate and our two measures of $\pi$, $\pi_1$ computed using the model and $\pi_2$ computed using univariate time series analysis. The computations use the coefficients reported in table 5.

Table 7

<table>
<thead>
<tr>
<th></th>
<th>$r_i$</th>
<th>$r_{ia}$</th>
<th>$r_l$</th>
<th>$r_{la}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_1$</td>
<td>0.20</td>
<td>0.26</td>
<td>0.27</td>
<td>0.35</td>
</tr>
<tr>
<td>$\pi_2$</td>
<td>0.30</td>
<td>-0.18</td>
<td>0.54</td>
<td>0.60</td>
</tr>
</tbody>
</table>

These estimates show no evidence of a negative relation between anticipated inflation and any of the measures of the expected real rate. Our use of the rate on 90 day bankers acceptances and ten year Treasury bonds differs from the Treasury bill rate used by Fama and Gibbons, but this difference is unlikely to explain fully the difference in results.

Recent, popular discussions of interest rates often point to the very high 'real' rates of interest. Such computations make no allowance for the increased risk resulting from increased variability of money growth. Allowing for the increase in variability shows that the average risk-adjusted 90 day rate, $r_i$, is 0.14% for the nine quarters following the change in monetary policy procedures. The average for $r_i$ in the preceding nine quarters of rising inflation is 1.63%. The change is within the range observed when the economy moves into a period of recession and stagnation.

6. Qualifications

The empirical findings reported in previous sections are subject to several qualifications or limitations. This section considers three of the limitations that can be analyzed empirically — the effect of the covariance, $\text{covar}(m_u, \epsilon_u)$, the effect of $\sigma_m$ and other measures of variability on the demand for money, and the effect of current deficits. Then, we mention some other qualifications that we have not analyzed in detail.

Table 8 reports on the effect of the covariance.\footnote{Before re-estimating the reduced form, we re-estimated $\pi$ and $\rho'$ using $\text{covar}(m_u, \epsilon_u)$.} There are no important
Table 8

<table>
<thead>
<tr>
<th></th>
<th>90-day rate</th>
<th>10-year rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-3.98</td>
<td>96.96</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td>(3.38)</td>
</tr>
<tr>
<td>(B-1)</td>
<td>-95.13</td>
<td>-46.66</td>
</tr>
<tr>
<td></td>
<td>(4.24)</td>
<td>(5.15)</td>
</tr>
<tr>
<td>(S-1)</td>
<td>-3.14</td>
<td>-0.94</td>
</tr>
<tr>
<td></td>
<td>(0.70)</td>
<td>(0.52)</td>
</tr>
<tr>
<td>(\sigma_m)</td>
<td>0.78</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>(3.84)</td>
<td>(4.44)</td>
</tr>
<tr>
<td>(\sigma_v)</td>
<td>0.30</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>(1.31)</td>
<td>(0.33)</td>
</tr>
<tr>
<td>(y^e)</td>
<td>62.09</td>
<td>16.72</td>
</tr>
<tr>
<td></td>
<td>(3.94)</td>
<td>(2.64)</td>
</tr>
<tr>
<td>(\pi)</td>
<td>0.87</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>(4.74)</td>
<td>(3.03)</td>
</tr>
<tr>
<td>(p^e)</td>
<td>85.74</td>
<td>50.90</td>
</tr>
<tr>
<td></td>
<td>(3.86)</td>
<td>(5.71)</td>
</tr>
<tr>
<td>Covar</td>
<td>0.03</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(0.96)</td>
<td>(1.08)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.84</td>
<td>0.94</td>
</tr>
<tr>
<td>(DW)</td>
<td>2.37</td>
<td>2.48</td>
</tr>
<tr>
<td>(SEE)</td>
<td>1.43</td>
<td>0.57</td>
</tr>
</tbody>
</table>

changes in magnitude or sign, and the covar term is not significant in the equations for 90 day or 10 year rates. We conclude that our assumption of zero covariance did not bias the results reported earlier.

Our hypothesis states that the demand for money increases with \(\sigma_m\). In the previous section, we used reduced form estimates to infer the effect of \(\sigma_m\) on the demands for base money and debt. We now introduce \(\sigma_m\), \(\sigma_v\), and covar \((m_u, v_u)\) into the type of demand function for real money balances \((M_1/p)\) found in recent literature. The measures of \(p^e\), \(\pi\) and \(y^e\) are the same as those used in earlier sections. Variables not used elsewhere are defined in the table. The time period, in all but one regression, is longer. Interest rate or income coefficients are, often, not significant by standard tests when computed from the shorter sample.

Table 9 shows these estimates. The effect of \(\sigma_m\) is uniform across equations. None of the equations show any significant effect of \(\sigma_v\), and only one shows a significant effect of the covariance term. This occurs when the expected rate of inflation is used [column (5)].
Table 9

The demand functions for $\log M_1/p$ (t-statistics in parentheses).*

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.20</td>
<td>-0.05</td>
<td>-0.01</td>
<td>+0.20</td>
<td>-0.23</td>
</tr>
<tr>
<td></td>
<td>(0.59)</td>
<td>(0.38)</td>
<td>(0.06)</td>
<td>(1.62)</td>
<td>(1.83)</td>
</tr>
<tr>
<td>$\gamma^*$</td>
<td>0.04</td>
<td>0.04</td>
<td>0.05*</td>
<td>0.06*</td>
<td>0.06*</td>
</tr>
<tr>
<td></td>
<td>(1.41)</td>
<td>(2.01)</td>
<td>(2.73)</td>
<td>(3.18)</td>
<td>(3.25)</td>
</tr>
<tr>
<td>$\sigma_m$</td>
<td>0.0031</td>
<td>0.0023</td>
<td>0.0021</td>
<td>0.0021</td>
<td>0.0021</td>
</tr>
<tr>
<td></td>
<td>(2.97)</td>
<td>(3.03)</td>
<td>(2.86)</td>
<td>(3.23)</td>
<td>(3.23)</td>
</tr>
<tr>
<td>$\sigma_s$</td>
<td>$+0.1 \times 10^{-3}$</td>
<td>$-0.7 \times 10^{-3}$</td>
<td>$-0.7 \times 10^{-3}$</td>
<td>$0.2 \times 10^{-3}$</td>
<td>(0.21)</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.82)</td>
<td>(0.82)</td>
<td>(0.82)</td>
<td>(0.21)</td>
</tr>
<tr>
<td>$i_T$</td>
<td>-0.009</td>
<td>-0.013</td>
<td>-0.014</td>
<td>-0.015</td>
<td>-0.006</td>
</tr>
<tr>
<td></td>
<td>(1.04)</td>
<td>(1.83)</td>
<td>(2.50)</td>
<td>(2.63)</td>
<td>(1.08)</td>
</tr>
<tr>
<td>$i_{90}$</td>
<td>-0.003</td>
<td>-0.002</td>
<td>-0.003</td>
<td>-0.002</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td>(3.72)</td>
<td>(5.18)</td>
<td>(5.68)</td>
<td>(5.86)</td>
<td>(4.98)</td>
</tr>
<tr>
<td>Cov</td>
<td>$0.2 \times 10^{-3}$</td>
<td>$0.5 \times 10^{-4}$</td>
<td>$0.5 \times 10^{-4}$</td>
<td>$0.3 \times 10^{-3}$</td>
<td>(2.51)</td>
</tr>
<tr>
<td></td>
<td>(1.21)</td>
<td>(0.43)</td>
<td>(0.40)</td>
<td>(0.40)</td>
<td>(2.51)</td>
</tr>
<tr>
<td>$\pi$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4.98)</td>
</tr>
<tr>
<td>$\log(M_1/p)-1$</td>
<td>0.99</td>
<td>0.97</td>
<td>0.95</td>
<td>0.90</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>(15.61)</td>
<td>(24.85)</td>
<td>(24.47)</td>
<td>(24.69)</td>
<td>(28.66)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.94</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
<td>0.98</td>
</tr>
<tr>
<td>$DW$</td>
<td>2.02</td>
<td>1.73</td>
<td>1.76</td>
<td>1.70</td>
<td>1.77</td>
</tr>
</tbody>
</table>

* $i_T$ is the level of the pass book rate; $i_{90}$ is the 90 day rate on commercial paper.
* Dependent variable is $\log M_1/p$, where $p^*$ is the rational expectations value. Lagged value is $\log(M_1/p)^{-1}$ in this regression.
* Indicates measured real income replaces $\gamma^*$.

To test that the effect of $\sigma_m$ in these equations is not a proxy for some other variable, we omit $\sigma_m$ (and $\sigma_s$ and cov) in column (4). The main effect is on the intercept of the equation. This suggests that $\sigma_m$ measures a separate influence on the demand for money and is not a proxy or correlate of the other variables in the equation. These findings support our hypothesis that unstable money growth increases the demand for money, given interest rates, income, and other factors.

The regressions reported in table 9 are subject to many, well-known criticisms. One of us expressed considerable skepticism about the use of lagged adjustment equations more than a decade ago. See Brunner and Meltzer (1968b). Our use of these equations is not intended as a test of these equations. The test is intended to show that, in these equations, $\sigma_m$ has a
significant, positive effect on the demand for real balances. Our results
support our hypothesis and the evidence from the reduced form equations.27
The magnitude of the effect of \( \sigma_m \) on the demand for money is smaller
than our estimate of the effect on base money. Using \( \Delta \sigma_m = 6 \), as before, the
coefficients in table 9 imply that the increase in \( \sigma_m \) raised average real money
balances by 1.2%. The difference between the effects on the demands for base
money and money suggests a proportionally larger effect on the demand for
currency than on the demand for demand deposits.

Deficit finance affects interest rates in our model by changing the base and
the outstanding stock of debt. During recent years, purchases of government
debt dominate the change in the base. Our findings support the conventional
propositions that increases in the base, initially, lower interest rates at all
maturities, lower short rates relative to long rates and raise expected prices.
Our findings provide evidence of homogeneity of money demands, but they
find no significant effect of debt finance in the reduced form equations.

7. Conclusion

A few quarters after the October 1979 change in monetary policy
procedures, our univariate time series analysis of the (logarithm of) money
stock shifted to a random walk. All memory of past history appears to have
been erased. The public acted as if each quarterly change in the growth rate
of money was a permanent change.

The Federal Reserve’s study of the first year of experience with the revised
control procedures notes that money growth and interest rates are positively
related, that changes in short-term and long-term rates are positively
correlated and that the variability of interest rates and money growth
increased. Board of Governors (1981). Their study does not offer an
explanation of the changes found in the date for 1979–1980 and in following
years.

Our study starts from the conjecture of Keynes (1936), and of Friedman
and Schwartz (1963) that increased variability (or instability) raises the
demand for money. We measure variability by computing moving standard
deviations of the unanticipated growth rates of money and velocity and
introduce these variables into the demand for money. Using an IS-LM
model, we show that increased variability raises interest rates.

The IS-LM model does not distinguish the effects on short- and long-term
rates. Our empirical work uses a version of the Brunner–Meltzer (1968a,

27The quarterly data on money used to construct the estimates of \( \sigma_m \) is mainly revised data,
not seasonally adjusted. We have not attempted to test for difference that would result from the
use of the data as first reported. We expect any difference between the two data sets to be more
important for weekly or monthly data than for quarterly data, but we believe it would be useful
to know more about the degree to which market responses are dominated by one or the other
data sets.
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1972) hypothesis, in which short- and long-term interest rates are determined simultaneously in the markets for money and debt (or money and credit). We test the hypothesis using data for the period prior to the 1979 change in monetary control procedures; then we re-estimate by including data for 1980 and 1981.

We find that unanticipated monetary variability has a significant, positive effect on short-term and long-term rates before and after the change in monetary procedures, but there is no evidence of an effect of unanticipated changes in the growth of velocity. We interpret the increase in variability after October 1979 as a measure of increased risk. Asset owners, faced with increased risk, appear to have shifted from real capital to money and short-term securities. Our model implies that the shift from real capital to money and (short-term) government securities raises the long-term rate of interest. The short-term rate rises also if the change in the long-term interest rate has a larger effect on the demand for government debt than on the demand for money. Our empirical findings suggest that this condition is met by a large margin.

The introduction of risk into the demand for assets helps to explain the positive correlation of interest rate changes across the maturity structure and the relatively flat yield curve at different levels of interest rates during the 1981–1982 recession. Increased variance of monetary variability can explain the increased variability of interest rates at all maturities that has been observed in recent years. The risk premium also explains the 'high' level of nominal rates and of nominal rates net of anticipated inflation. We show that, once allowance is made for the risk premium as well as expected inflation, the average 90 day real rate in 1980–1981 is approximately 0.1%. Our measures of the risk premium in short-term and long-term rates are 3.3% and 1.3% respectively, on average for these years.

These findings suggest that the risk premium in short- and long-term rates prolonged the recession by reducing the demand for real assets and for output. Our model and estimates are consistent with the decline in prices and measured rates of inflation, the stagnant economy and the observed increase in the demand for money per unit of income. Although we do not provide an underlying micro model of risk and asset demand, our model is in accord with recent theoretical work by Peled (1982) and some of the implications in Cosimano (1982).

Increases in the growth rate of the base raise the expected rate of inflation and, thus, raise market rates at all maturities. Changes in debt have much smaller effects on interest rates and prices, but by using homogeneity conditions, we find effects on short- and long-term rates.

Our efforts to test for any additional effect of the deficit may depend on the measure of the deficit chosen. Using nominal and deflated values of the reported deficit in the equations of table 5, we find no significant effects of
the deficit on $i$ and $l$. In all cases examined, the computed effect is negative and not significantly different from zero.

The remaining limitations are more costly or difficult to remove. Although we update our estimates of $\sigma_m$ and $\sigma_x$ after 1980-I, most of the values of these variables, and of $y^e$, $\pi$ and $p^e$ are estimated over the entire sample period. This procedure uses more information to construct expected values than people have when they make decisions. Also, our estimates of $\sigma_m$, $\sigma_x$, and covar are computed from innovations in time series models of money growth and velocity growth and not as part of the expectations of the stock of money and the level of output used in the model.\(^{28}\) Further, our model is static and is not derived from a maximizing model in which individuals choose portfolios of money, debt and claims to real capital.

These, and other departures, from a well-specified, rational expectations, dynamic model introduce possible errors and misspecifications into our equations. We have attempted to compensate, at least in part, by testing our model in a period not subject to the more variable money growth that followed the change in Federal Reserve procedures, by re-estimating the equations with additional data for the later period, by comparing our estimates of the effect on the demand for money to estimates obtained using a conventional equation, and in other ways.\(^{29}\)

The data suggest that the October 1979 change in monetary policy procedures moved the economy to a socially inefficient point. Recent policy procedures do not minimize risks; this is shown by the fact that the variability of interest rates at all maturities and the variability of money growth increased after 1979. A socially more efficient procedure for managing money appears to be capable of reducing the variability of both money growth and interest rates. Adoption of a more efficient procedure appears capable of reducing the risk premium, lowering the interest rates, increasing the demand for real capital and assisting the economy to move to a higher level of output without increasing money growth or inflation.

\(^{28}\)The problem is likely to be greater for $\sigma_x$ than for $\sigma_m$. The reason is that $\sigma_x$ includes responses of the growth rate of the demand for money to the instability introduced by monetary policy. A further problem is the absence of a measure of fiscal instability or the instability of unanticipated growth in public debt.

\(^{29}\)After the paper was completed, we were pleased to learn that Bomhoff (1983) finds supporting evidence for the U.S., Germany and some other countries using a similar procedure. Bomhoff estimates that the effect of increased monetary uncertainty raised U.S. long-term rates by 2 to 2.5 percentage points between 1978 and 1981-2. Like us, he finds no significant effect of budget deficits.
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