INFLATIONARY EXPECTATIONS, MONEY GROWTH, AND THE VANISHING LIQUIDITY EFFECT OF MONEY ON INTEREST: A FURTHER INVESTIGATION

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I.
INTRODUCTION

An important issue in discussion of the transmission mechanism of monetary policy is the response pattern of nominal interest rates to changes in the growth rate of money. The traditional analysis of the effects of changes in money growth on nominal interest rates runs in terms of liquidity, income, and expectations effects.[1] Consider an increase in the growth rate of money. Initially, there is an excess supply of money at the existing income, interest rate, and the price level. If the price level and real income adjust slowly, then the nominal interest rate must decline in order to equate money demand and money supply. This initial fall in the nominal and real[2] interest rates is known as the liquidity effect. Over time, nominal income will rise following the increased growth rate of money and this rise in nominal income will increase money demand which in turn leads to higher interest rates. This is the income effect of money on the nominal interest rate. Finally, there is a Fisher or expectations effect as nominal interest rates increase due to a rise in inflationary expectations induced by the higher money growth rate.[3]

The important assumption underlying this description of the time pattern of the effects of higher money growth on interest rates is that income and expectations effects of a current acceleration in money growth occur with a lag as the income and the price level are slow to adjust. If this assumption is not valid, for example, if the expectations effect of higher money growth occurs rapidly or if there is a reduction in the lag in the effect of money on income, the liquidity effect will not be observable.

The early empirical work which examined the time pattern of the effects of higher money growth on interest rates seemed to confirm the previously described stylized pattern. In particular, this work showed the presence of a statistically significant liquidity effect.[4] However, the results of more recent empirical work on this issue have been mixed.[5] Mishkin (1981, 1982) recently suggested that the liquidity effect of money on interest did not exist, and Melvin's (1983) work implies that the liquidity effect existed in the '50s and the '60s but vanished in the '70s. Makin (1983), on the other hand, reports evidence consistent with the presence of a statistically significant but quantitatively weak liquidity effect.[6]

This paper has two objectives. The first objective is to investigate further the existence of the liquidity effect using an improved estimation methodology.

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[1] Friedman (1968, 1969), Cagan (1972), Cagan and Gandolfi (1969, Gibson (1970), Darby (1975), Carlson (1979), and Melvin (1983).

[2] If the price level and inflationary expectations adjust slowly, a reduction in the nominal interest rate implies reduction in the real rate.

[3] If the higher level of inflationary expectations has no effect upon the steady state value of the real rate, then, the nominal interest rate will rise by the full amount of the rise in inflationary expectations. An avenue through which higher money growth can affect the real rate is discussed in Mundell (1963).

[4] Gibson (1970), Cagan and Gandolfi (1969), and Cagan (1972). For a recent confirmation, see Melvin (1983).

[5] Mishkin (1981, 1982), Melvin (1983), and Makin (1983).

[6] In Makin's framework, only unanticipated increases in money growth can depress nominal and real interest rates. Anticipated increases in money growth are not at all associated with declines in interest rates. Moreover, the magnitude of the reduction in interest rates associated with a given positive money surprise is very small. A positive money surprise over a quarter at a 1 percent annual rate depresses the short-term interest rate by 2 to 3 basis points. This implies that if the Fed wants to depress short-term interest rates by 100 basis points in a given quarter, then positive money surprises over a quarter at a 33 percent to 50 percent annual rate are needed.

The existing empirical work employs the questionable assumption that the money growth variable is strictly an exogenous regressor.[7] This is a questionable assumption in view of the way that monetary policy has been conducted. Policy has been aimed at fostering the attainment of macroeconomic objectives such as sustained economic growth, full employment, and low inflation. But in seeking to achieve these objectives, the Federal Reserve has used as guides such financial variables as the monetary aggregates and money market interest rates. Over much of the last three decades, considerable weight has been given to money market conditions and to dampening swings in interest rates. Furthermore, in more recent periods when greater weight has been placed on the monetary aggregates, financial innovations and deregulation of the financial markets occasionally have combined to make money demand a less useful guide to monetary policy, thus forcing the Federal Reserve to place added emphasis on interest rates at the expense of the monetary aggregates. In view of the above considerations, the money growth variable is likely to be correlated with the disturbance term in the usual nominal interest rate regressions. The use of ordinary least squares to estimate the time pattern of the effects of higher money growth on interest rates, therefore, may provide inconsistent estimates of the existence of the liquidity effect. This paper uses a consistent estimation procedure to investigate the existence of the liquidity effect.

The second objective of this paper is to provide some empirical evidence on Milton Friedman's view (1968) that the presence of the liquidity effect of higher money growth depends upon the nature of the response of expected inflation to higher money growth. Friedman (1968) has argued that in a high inflationary environment, inflationary expectations become so responsive to money growth that the expectations effect may be strong enough and prompt enough to overpower the short-run liquidity effect. Since the United States experienced rising inflation in the late '60s and the '70s, Friedman's argument would imply a reduction in the magnitude of the liquidity effect during that time period. This implication will be tested in this paper.

The rest of the paper is organized as follows. Section II presents a simple model of interest rate determination and defines the liquidity effect in the context of this model. It discusses the relevance of the nature of the monetary policy regime in getting consistent estimates of the parameter measuring the existence of the liquidity effect. It also reviews the argument made by Friedman (1968), noted above. Section III reports the empirical results, and Section IV contains the main conclusions and some policy implications.

II.

EXPLANATION OF METHODOLOGY

A Model of Interest Rate Determination, the Liquidity Effect, and the Behavior of the Federal Reserve

Economists have long been interested in investigating the time pattern of the effects of money growth on nominal and real interest rates. The analytical framework that underlies the empirical investigation differs widely among these economists. However, in each case, inferences about the existence of the liquidity effect are based upon a nominal interest rate regression in which money growth appears either as the sole regressor or as one of the right-hand side regressors.[8] A common assumption made in this

[7] In a regression equation, a right-hand side explanatory variable is not exogenous if it is contemporaneously correlated with the disturbance term. In that case, the use of ordinary least squares to estimate the regression parameters will produce estimates which have some undesirable properties. In particular, the estimates will be inconsistent meaning they do not converge to the true values of the parameters as the sample size becomes very large. Therefore, the ordinary least squares estimation procedure is an inconsistent estimation procedure in the presence of an endogenous regressor in the regression equation. However, there exists alternative estimation procedures which can produce consistent estimates of the parameters. Such estimation procedures are sometimes referred to as consistent estimation procedures.

[8] Basically, three approaches have been used to study this issue. One of these is to estimate distributed lag regressions of nominal interest rates on money growth by ordinary least squares and to infer the existence and strength of the liquidity effect from examining the sign and size of the coefficients on the first few lags of the money growth variable; here money growth is the only right-hand side explanatory variable (Melvin (1983)). The second approach employed is to specify explicitly an IS-LM-Aggregate Supply model of the economy and estimate by ordinary least squares the associated reduced form for the nominal interest rate. In this framework, money growth is only one of the right-hand side regressors, which also include a proxy for expected inflation. The presence of the liquidity effect is inferred by examining the sign and size of the coefficient on the money growth variable (Makin (1983), Peek and Wilcox (1984)). The third approach uses the efficient markets-rational expectations theory. If bond markets are assumed to be efficient, then nominal yields will deviate from their equilibrium values only when new information appears on the market. In this framework, changes in nominal yields are regressed upon surprise (i.e., actual minus anticipated) changes in information variables like money growth, inflation, real income, and the presence of the liquidity effect is inferred by examining the sign and size of the coefficient on the surprise money growth variable (Mishkin (1981, 1982)). Here money growth again is one of the right-hand side regressors.

empirical work, that money growth is an exogenously determined variable, allows one to use ordinary least squares to estimate the parameters of the nominal interest rate regressions. As noted above, this assumption is questionable in view of the way the Federal Reserve has conducted its monetary policy.[9]

In order to explain the issues involved as well as motivate the empirical work reported here, this paper investigates the existence of the liquidity effect using the most widely employed (Fisher equation) approach to interest rate determination.[10] This approach amounts to estimating the standard Fisher equation in which the determinants of the real rate are explicitly specified by means of an IS-LM model augmented by some sort of Aggregate Supply or Phillips curve relation. The sign and size of the estimated coefficient appearing on the money growth variable in the associated Fisher equation is then used to infer the existence and magnitude of the liquidity effect. Consider the following simple IS-LM-Aggregate Supply model:[11]

$$\text{IS:}\quad i(1-T) - \pi = \alpha_0 + \alpha_1 (X-Y^n) - \alpha_2 (Y-Y^n) - \alpha_3 SS + \alpha_4 Z_t + U_{1t}, \quad \alpha_1, \alpha_2, \alpha_3, \alpha_4 > 0, \tag{1}$$

$$\text{LM:}\quad i(1-T) = \frac{b_0}{b_2} + \frac{b_0}{b_2}(Y-Y^n) + \frac{1}{b_1}(P-M+Y^n) + U_{2t},^{12} \quad b_1, b_2 > 0, \tag{2}$$

$$\text{AS:}\quad P = c_0 + P^e + c_1 (Y-Y^n) + c_2 SS + U_{3t}, \; c_1, c_2 > 0, \tag{3}$$

where all the variables except i and Z are in natural logs and where Y is actual real output, Y^n is the natural real output, X is the exogenous component of aggregate real demand, M is the nominal money stock, P is the price level, P^e is the expected price level, i is the nominal interest rate, SS is the supply shock variable measuring the relative price of energy, Z is the percentage change in real output lagged one period, T is the average marginal tax rate on interest income, and Us, s=1,2,3, are stochastic error terms.[13]

Figure 1 presents graphs of the IS, LM, and aggregate supply (AS) equations. Equation (1) is the equation of the IS curve showing an inverse relationship between the after-tax nominal rate $i(1-T)$ and real output $(Y-Y^n)$; its position depends upon the exogenous component of the real demand X, the expected inflation rate π, the lagged growth in real income Z, and the supply shock variable SS. Equation (2) is the equation of the LM curve showing a positive relationship between the after-tax nominal rate $i(1-T)$ and real output $(Y-Y^n)$; its position depends upon the price level P and the nominal money stock M. Equation (3) is the equation of the aggregate supply curve implying a positive relationship between the price level and real output; its position depends upon the expected price level P^e and the supply shock variable SS. U_1, U_2, and U_3,

[9] There is another set of very recent papers which looks at the responses of asset prices (or nominal asset yields) to the weekly money stock announcements (Urich (1982, 1984), Grossman (1981), Cornell (1982, 1983a, 1983b), and Gavin and Karamouzis (1984)). In these studies, changes in asset prices are generally regressed upon surprise changes in the weekly money stock numbers. There are two important assumptions underlying this work. The first is that the weekly money stock numbers have a predictive content for the future money stock. The second is that the asset markets are efficient and that the asset prices will respond to any new information contained in these money stock announcements. It is then argued that the predictive content of money stock announcements and the response of asset prices to new information in the announcements vary with changes in the way the Federal Reserve formulates and implements the monetary policy. The implication is that changes in the response of asset prices to money stock announcements can enable us to infer the public's perception of the policy making.

Since the money announcement studies focus on explaining changes in asset prices in the very short run—the period immediately following the announcement—and since information about other potentially related factors is not included in these regressions, one could not necessarily infer the existence of the liquidity effect from examining the sign of the estimated regression coefficient on the money announcement variable in a given asset price regression.

[10] Sargent (1972), Levi and Makin (1978), Peek (1982), Wilcox (1983), Makin (1983), and Peek and Wilcox (1984).

[11] This macromodel is in essence similar to the ones given in Peek (1982), and Wilcox (1983). For a detailed description, see Mehra (1984).

[12] The demand equation for real money balances underlying the LM curve is assumed to be $(M-P-Y^n)^d = b_0 + b_1 (Y-Y^n) - b_2 i(1-T)$. Assuming that the money supply equals money demand, we can solve the equilibrium expression for the after-tax nominal interest rate to get equation (2) of the text.

[13] X captures the effects of changes in the autonomous components of aggregate real demand such as real exports and real government expenditures. Z proxies for the effect of income induced investment expenditures, the so-called investment accelerator effect. SS captures the effect of changes in the relative price of energy. The model is short run in nature and focuses on the cyclical behavior of the economy. Therefore, actual real output is measured relative to its natural level, and some other variables are similarly normalized. For example, X is normalized dividing it by the natural real output. In this context, p^e is to be viewed as the expectation held at time t−1 of the price level at time t. Actual real output will deviate from its natural level whenever the actual price level (P) differs from its anticipated level (P^e) (see equation (3) in the text).

respectively, are the stochastic error terms appearing in the IS, LM, and AS relationships.

In order to derive the Fisher equation associated with this macromodel, we can combine equations (1) through (3) to get the following:

$$i_t = (1/(1-T)) \, [A_0 + A_1 X_t + A_2 SS_t + A_3 DM_t + A_4 Z_t + A_5 \pi_t] + V_t, \qquad (4)$$

where DM_t is $(M-P^e-Y^n)$, and where A_1, A_2, A_3, A_4, and A_5 are the parameters in the nominal interest rate equation.[14] The stochastic term V_t in (4) is the reduced form disturbance term and is related to the stochastic terms appearing in the IS, LM, and AS relationships in the following way:

$$V_t = ((c_1 + b_1) \, U_{1t} + \alpha_2 U_{2t} + \alpha_3 U_{3t})/(d), \qquad (5)$$

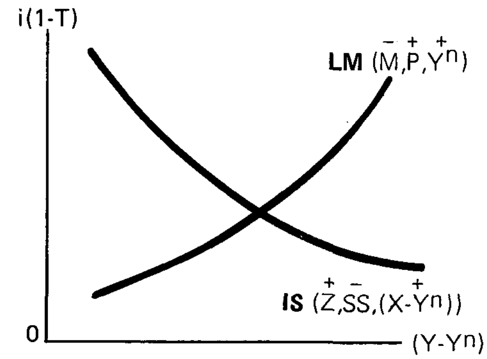
where $d \equiv (b_1 + c_1 + b_2 \alpha_2)$. It can be easily shown[15] that in the nominal interest rate equation (4), the nominal interest rate responds positively to increases in expected inflation $(A_5 > 0)$, the exogenous component of real demand $(A_1 > 0)$, and real income $(A_4 > 0)$. The supply stock variable has an uncertain effect upon the nominal interest rate $(A_2 \gtreqless 0)$. The coefficient in front of the money stock variable is negative $(A_3 < 0)$, implying that higher money stock depresses the nominal interest rate. Equation (5) is important for the later discussion as it shows that the stochastic shifts occurring in the IS, LM, and AS relationships can cause stochastic shifts in the nominal interest rate equation (4) and thus cause the actual nominal interest rate to deviate *in the short run from the value implied by* the behavior of expected inflation, autonomous real demand, relative price of energy, and money stock. In this framework, the existence of the liquidity effect is investigated by examining the statistical significance of the parameter A_3, which is usually estimated with ordinary least squares.

The main question is whether it is appropriate to estimate the nominal interest rate equation (4) by the ordinary least squares estimation procedure. If any one of the right-hand side explanatory variables appearing in (4) is correlated with the error term V_t, then the ordinary least squares estimates of the parameters are inconsistent and this may yield an incorrect inference about the existence of the liquidity effect. Of interest here is the possibility that the error term V_t may be correlated with the money growth variable due to the way the Federal Reserve implements its monetary policy.

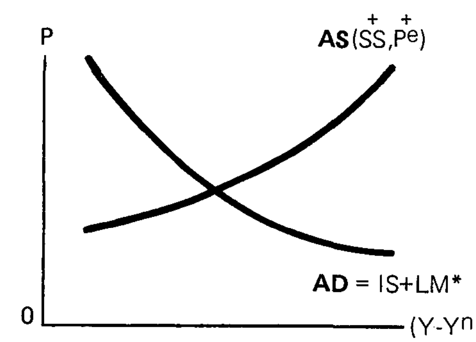
Consider the case in which the Federal Reserve conducts monetary policy by focusing solely on the monetary aggregates. In this case, any random rise in the nominal interest rate $(V_t > 0)$ as a result of a

Figure 1

IS AND LM CURVES



AGGREGATE SUPPLY AND AGGREGATE DEMAND CURVES



*Aggregate demand curve (**AD**) is derived by combining the **IS** and **LM** curves.

[14] Equation (4) is the standard Fisher equation adjusted to allow for the presence of taxes. To see this, rewrite (4) as

(a) $i_t = r_t^e + (1/(1-T)) \, A_5 \pi_t + V_t$,

where r_t^e is the after-tax expected real rate assumed to be approximated by the following relationship

(b) $r_t^e = (1/(1-T)) \, [A_0 + A_1 X_t + A_2 SS + A_3 DM_t + A_4 Z_t]$.

Equation (a) is the standard Fisher equation as one can view r_t^e as the expected real rate component of the nominal interest rate.

[15] For details, see Mehra (1984).

random shift occurring in the IS, the LM, or the AS relationship is not offset by the Federal Reserve letting money growth (M) deviate from its targeted value. Here, the money growth variable is likely to be predetermined and not correlated with the error term V_t.

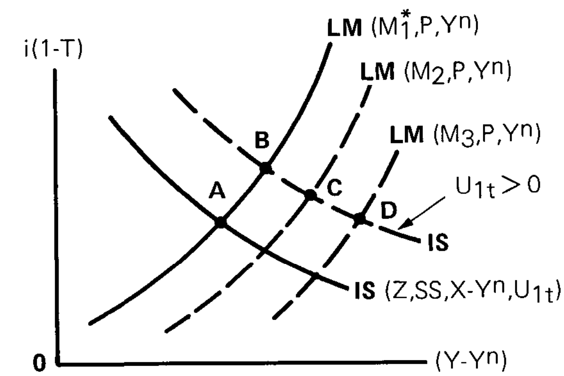
However, if the Federal Reserve, though still focusing on the monetary aggregates, does partially smooth interest rates, then a positive correlation between DM_t and V_t may exist. Consider, for example, a stronger than expected increase in the exogenous component of real demand causing an upward random shift in the IS relation ($U_{1t} > 0$). It is clear from equation (5) that a positive shock in the IS relation will cause a positive shock ($V_t > 0$) in the nominal interest rate equation (4). This will cause the nominal interest rate to rise. If the Federal Reserve decides to prevent or reduce the extent of this rise, it would let the money stock (M) rise and thereby create a positive covariance between DM_t and V_t.[16] In this case, it can be easily shown that the ordinary least squares estimation procedure will generate an inconsistent estimate of the liquidity effect parameter A_3.[17]

The extent of the least squares bias in the estimate of the liquidity effect parameter in equation (4) becomes more severe if the Federal Reserve conducts monetary policy focusing on interest rates. In the limiting case in which the Federal Reserve fixes a nominal rate and stands ready to maintain it, a regression equation like (4) is not relevant. This is so because the nominal rate is predetermined in this case, and the nominal money stock simply responds to any discrepancy between the actual and the targeted value of the nominal interest rate. In fact, if the Federal Reserve is successful in this interest rate pegging policy, the regression of the nominal rate on the right-hand side explanatory variables as in (4) should yield a coefficient on the money growth variable which is not statistically different from zero.[18]

The basic point is further illustrated in Figure 2 which shows an initial equilibrium point A in the IS-LM diagram. Consider a positive stochastic shock to the IS relationship, arising, say, from a stronger than anticipated increase in the aggregate demand. This shock causes the IS curve to shift upward, moving the (partial) equilibrium point from A to B

Figure 2

IS AND LM CURVES



All variables are as defined in the text. U_{1t} is the stochastic error term in the **IS** relationship, and M_1^* is the targeted level of the money stock. M_2 and M_3 are actual levels of the money stock, $M_3 > M_2 > M_1^*$.

[16] It should be kept in mind that the correlation between DM_t and V_t is mainly due to correlation between M_t and V_t.

[17] The nature of the bias in the estimated parameter is likely to be positive. This point can be easily demonstrated. Consider the following simple version of the interest rate equation

$$i_t = a + b\,M_t + c\,P_t + V_t,$$

where i is the nominal interest rate, M is the money growth variable, P stands for other variables appearing in the equation, and V is the disturbance term. The parameter b is hypothesized to be negative, and it measures the liquidity effect. If this equation is estimated by ordinary least squares, it can be shown that the probability limit (plt) of the least squares estimate of b can be expressed as:

$$plt(b) = [b + (COV(M,V)\ COV(P,P) - COV(P,V)\ COV(M,P))/(D)],$$

where D is $[COV(M,M)\ COV(P,P) - COV(M,P)^2]$ COV (M,V) is the covariance between M and V, and COV(P,P) is the variance of P. Other terms can be interpreted in a similar fashion. If the explanatory variables are contemporaneously uncorrelated with the error term V (COV (M,V) = COV (P,V) = 0), it is clear that plt (b) equals b, and the above regression provides a consistent estimate of the liquidity effect. But suppose that M and V are positively correlated, then it is clear that plt (b) equals [b + (COV (M,V) COV(P,P))/(D)]. Since both D and COV(P,P) are positive, the presence of the positive covariance between M and V causes a bias in the estimate of the liquidity effect parameter.

[18] In this case, the nominal interest rate regression like (4) is likely to be viewed as representing possibly the reaction function of the Federal Reserve. Therefore, the response of the nominal interest rate to variables other than money growth will depend upon the time period for which the interest rate is pegged and the considerations which cause the Federal Reserve to change the rate it pegs.

and resulting in upward pressure on the after-tax nominal interest rate. If the Federal Reserve does not smooth interest rates, the actual money stock stays at M_1^*, the targeted level. But if the Federal Reserve does smooth interest rates, it may let the actual money stock rise to M_2, resulting in a new equilibrium at point C in Figure 2. At this point, we have a higher money stock and a higher level of the after-tax nominal interest rate (compare A and C in Figure 2). On the other hand, if the Federal Reserve decides to eliminate completely the rise in the nominal interest rate, it may cause the money stock to rise enough to yield the equilibrium point D shown in Figure 2. Here, we have higher money stock ($M_3 > M_1^*$) accompanied by no important change in the nominal interest rate. Thus, a positive stochastic shock to the IS relationship combined with a partial smoothing of interest rates creates a positive correlation between money and the error term in the nominal interest rate regression.

Inflationary Expectations and Money Growth: Is the Liquidity Effect Temporally Stable?

An important assumption underlying the existence of the liquidity effect is that the price level and real income do not adjust fully as the money supply changes. In the context of the present model higher money growth is associated with a reduction in the nominal interest rate ($A_3 < 0$ in equation (4)) provided the expected inflation rate variable π_t is not immediately affected by the current acceleration in money growth. If the expectations effect of higher money growth occurs rapidly, then higher money growth may not depress the nominal interest rate, even in the short run.

As noted before, Friedman (1968) has argued that the liquidity effect of higher money growth will not be found in countries which have long experienced high inflation. His point is that in a high inflationary environment, inflationary expectations will become more responsive to money growth and the expectations effect of higher money growth will therefore occur rapidly.

In order to investigate the empirical validity of Friedman's argument, this paper examines the temporal stability of the liquidity effect. The average U. S. inflation rate observed in the late '60s and the '70s was certainly higher than that observed in the '50s and the early '60s. Moreover, there has also occurred an increased awareness of the role of money growth in causing inflation. In view of these considerations, one may expect to find a) an increase in the responsiveness of inflationary expectations to higher money growth, and b) a decrease in the magnitude of the liquidity effect over time. Empirical evidence on these issues is provided by examining the temporal stability of the liquidity effect parameter A_3 in the nominal interest rate equation (4). Since the empirical work in this paper uses the Livingston survey measure of expected inflation as a proxy for inflationary expectations, the Livingston measure's sensitivity to higher money growth over time can also be examined.

III.

EMPIRICAL RESULTS

This section reports the empirical results concerning the existence, magnitude, and temporal stability of the liquidity effect. In order to examine the sensitivity of inflationary expectations to higher money growth, equations explaining the formation of inflationary expectations are reported and their stability over time is investigated.

In an attempt to capture empirically the liquidity effect of money on interest rates, the monetary variable is measured in growth form and is represented by the current growth rate of the nominal money stock relative to its most recent trend growth rate. It is these accelerations or decelerations in nominal money growth relative to normal that are likely to affect the real interest rate and generate the liquidity effect. Changes in the nominal money stock induced by a constant trend growth rate of money are likely to be reflected in prices and hence are likely to leave unchanged the real rate.[19]

As stated before, the short-term U. S. monetary policy stance has been constrained by, among other things, the Federal Reserve's concern to promote a stable environment in the financial markets.[20] This

[19] Cagan and Gandlofi (1969), Gibson (1970), and Melvin (1983). See also Carlson (1979) and Wilcox (1983) who employ this measure of money growth. It should be noted that the money stock variable is not divided by the expected price level and the natural real output.

[20] For a description of how the Federal Reserve's ongoing desire to avoid disorderly conditions in financial markets shaped monetary policy in the '50s, the '60s, and the early '70s, see Lombra and Torto (1975). For some empirical evidence on the same issue, see De Rosa and Stern (1977), Feige and McGee (1979), and the references cited in them. For a more recent review of U. S. monetary policy, see Poole (1982) and Axilrod (1985). The paper by Axilrod (1985) provides a good discussion of several other exogenous forces that might have led the Federal Reserve to deemphasize the monetary aggregate (M1) in the short-run formulation of monetary policy.

concern has led the Federal Reserve at various times to dampen fluctuations in interest rates. Hence the money growth variable in the nominal interest rate regression (4) is likely to be correlated with the error term. The interest rate regressions reported in this paper are therefore estimated employing an instrumental variable estimation procedure.[21]

Table I reports estimates of the nominal interest rate equation (4) for two sample periods 1952-1979 and 1952-1983. These estimates, which are obtained using the instrumental variable estimation procedure with a first-order serial correlation correction, imply that most of the explanatory variables have the expected influence on the behavior of the nominal interest rate. That is, rises in expected inflation (PE12), exogenous components of aggregate demand (X), and lagged real income growth (Z) raise interest rates while positive supply shocks (SS) lower them. (See coefficients on these variables in Table I).[22]

However, the coefficient measuring the effect of accelerations in money growth on the nominal interest rate (coefficient on LIQ in Table I) is negative but statistically insignificant at the conventional significance level. The estimates based on the full sample periods therefore do not support the presence of a statistically significant liquidity effect.

Table II reports estimates of the nominal interest rate equation over various subperiods. In order to separate the earlier, low-inflation period from the high-inflation period which starts in the mid-'60s, the full sample period is split at the end of 1965 and the estimates of the interest rate equation so obtained are presented in rows 1, 3, and 4. Melvin (1983)

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[21] The basic idea behind the instrumental variable estimation procedure is to seek out the variables—called instruments—which are correlated with the endogenous variable in question but not correlated with the error term in the regression equation. The instruments are then used to generate estimates of the regression parameters, which are generally consistent.

[22] The data used are semiannual observations corresponding to the Livingston survey data collected each June and December. Monthly averages of 1-year Treasury bill yield during June and December are used for the nominal interest rate. Second- and fourth-quarter observations are used for the variables measuring the exogenous component of aggregate demand (X), supply shocks (SS), and real income growth (Z). X is the logarithm of the sum of real exports and real government expenditure on goods and services divided by the level of natural real output. The Rasche-Tatom series on the potential GNP constructed at the Federal Reserve Bank of St. Louis is used as a proxy for the natural real output. SS is constructed by taking the ratio of the deflator for imports to the GNP deflator and multiplying this ratio by the nominal effective dollar exchange rate index constructed by the Morgan Guaranty Trust. The latter step eliminates the effect of exchange rate changes on the import deflator. Z is the percentage change in the real GNP lagged one quarter. The data on the LIQ variable were generated using June and December observations on M1 according to the following relationship:

$$LIQ = ((M_t/M_{t-1})^2-1)-((M_{t-1}/M_{t-7})^{1/3}-1).$$

Table I

ESTIMATES OF THE INTEREST RATE EQUATION, SEMIANNUAL DATA, INSTRUMENTAL VARIABLE PROCEDURE WITH A CORRECTION FOR SERIAL CORRELATION

	Coefficients On							
Sample Period	PE12	LIQ	SS	X	Z	$\bar{R}^2$	SER	DW/ρ
1952.06-1979.12	.56	−8.8	−2.4	6.2	8.9	.97	.676	2.0/.29
	(15.7)	(1.4)	(−3.9)	(2.7)	(2.1)			
1952.06-1983.12	.54	−9.2	−2.6	5.8	6.1	.98	.765	2.0/.12
	(17.2)	(−1.1)	(−4.2)	(2.6)	(1.4)			

Notes: The nominal interest rate equation estimated and reported above is from the text (equation (4)) and can be expressed, using proxy variables as

$$i = (1/(1-T))[A_0 + A_1 X + A_2 SS + A_3 LIQ + A_4 Z + A_5 PE12],$$

where i is the average market yield on a one-year Treasury bill, X is the normalized value of real exports and real government expenditure, SS is the ratio of the deflator for imports and deflator for GNP adjusted for changes in the exchange rate, PE12 is the Livingston survey forecast of inflation over the 14-month horizon, LIQ is the annualized growth rate of the nominal money stock over the last six months minus its annualized growth rate over the last three years (Carlson 1979, Wilcox 1983), T is the series on the average marginal tax rate prepared by Joe Peek (1982), and Z is the lagged value of the rate of growth of the real GNP. The interest rate equation is estimated employing the instrumental variable procedure, and the data used are semiannual observations corresponding to the Livingston survey data collected each June and December. The instruments used are the current and lagged values of PE12, SS, X, and Z and lagged values of LIQ and i. The estimation corrects for the presence of the first-order serial correlation. The interest rate equation for the period 1952.06-1983.12 includes a dummy which takes value one in 1981.06-1983.12 and zero otherwise; it also includes a credit control dummy. $\bar{R}^2$ is R^2 adjusted for degrees of freedom, SER is the standard error of the regression, DW is the Durbin-Watson statistic, and ρ is the serial correlation coefficient. The parentheses contain t values.

See footnote 22 for further details on the data.

Table II

ESTIMATES OF THE INTEREST RATE EQUATION OVER VARIOUS SUBPERIODS, SEMIANNUAL DATA, INSTRUMENTAL VARIABLE PROCEDURE WITH A CORRECTION FOR SERIAL CORRELATION

Sample Period	Coefficients On					$\bar{R}^2$	SER	DW/ρ
	PE12	LIQ	SS	X	Z			
1. 1952.06-1965.12	.85	−17.4	−1.9	4.3	11.2	.95	.644	2.1/.08
	(3.0)	(−2.3)	(−1.3)	(1.3)	(2.0)			
2. 1952.06-1970.06	.75	−15.1	−2.0	2.7	11.0	.97	.611	2.1/.08
	(5.7)	(−2.9)	(−1.6)	(1.4)	(2.3)			
3. 1966.06-1979.06	.78	−4.5	−4.3	11.9	9.1	.99	.684	1.9/.09
	(6.3)	(.6)	(−3.9)	(3.8)	(1.3)			
4. 1966.06-1983.12	.73	−1.6	−4.0	10.0	1.4	.99	.844	2.0/0.0
	(6.7)	(−.2)	(−3.6)	(3.6)	(.2)			
5. 1970.12-1979.06	.91	6.1	−4.5	13.5	10.3	.99	.622	1.97/−.2
	(6.9)	(.5)	(−4.0)	(1.5)	(1.5)			
6. 1970.12-1983.12	.85	−.9	−4.1	4.4	2.9	.99	.817	2.1/−.3
	(6.9)	(−.1)	(−3.9)	(.6)	(.4)			

Note: See Table I notes.

has argued that a significant change in the response of nominal interest rates to higher money growth occurred in the early '70s, not in the mid-'60s. Rows 2, 5, and 6 present estimates obtained by splitting the sample in 1970.[23]

The estimates obtained for the coefficient associated with accelerations in money growth in the nominal interest rate equation in the low-inflation period clearly imply the existence of a strong and statistically significant liquidity effect (see the coefficient on LIQ presented in rows 1 and 2 in Table II). These estimates imply that one percent positive deviation in the money growth from its most recent trend growth rate reduces the nominal interest rate by 15 to 17 basis points. However, the estimates obtained for the high-inflation period imply the complete disappearance of this liquidity effect (see the coefficient on LIQ presented in rows 3, 4, 5, and 6 in Table II). There is a drastic reduction in the size of the liquidity effect parameter, and it is never statistically significant. These results together then imply that the liquidity effect is not temporally stable; there does not appear to exist a significant liquidity effect over the high inflation period comprising the mid-'60s and the '70s.[24]

In a high-inflation period, inflationary expectations may adjust rapidly and become more sensitive to higher money growth. Therefore, the money growth variable, when introduced as an additional regressor in a nominal interest rate regression that already contains the variables capturing the expectational (and perhaps real income) effects associated with higher money growth, may not add to the explanatory power of the equation, i.e., there may not be the liquidity effect associated with higher money growth. Since inflationary expectations here are proxied by the Livingston survey measure of the expected inflation rate,[25] one may explain the change in the response of the nominal interest rate to higher money

[23] It is not the intent of this paper to search for the exact date where there was a significant change in the structure. However, these two ways of splitting the full periods may broadly be viewed as an attempt to separate the low-inflation period from the high-inflation period.

[24] It might be pointed out that this result about the temporal instability of the liquidity effect is not due to the use of the instrumental variable estimation procedure. The ordinary least squares estimation of these interest rate equations yields a similar inference about the vanishing of the liquidity effect over the high-inflation period. However, the two estimation procedures yield rather different estimates of the magnitude of the liquidity effect over the low-inflation period. The instrumental variable estimation procedure yields estimates of the liquidity effect which are stronger than those produced by the ordinary least squares procedure.

[25] This practice is widespread; see Levi and Makin (1978), Carlson (1979), Peek (1982), Makin (1983), and Peek and Wilcox (1984).

growth in terms of the change that may have occurred in the formation of this survey measure of the expected inflation rate. Is there any evidence to support the view that inflationary expectations as measured by this survey measure are sensitive to money growth and that this sensitivity may have increased over time?

Tables III and IV report some estimates of the equations explaining the formation of inflation expectations by the Livingston survey participants.[26] In an attempt to identify the important variables economic agents look at in forming expectations of inflation, Table III presents several regression equation estimates obtained when the survey measure of expected inflation is regressed on a vector of variables plausibly related to inflation,—namely (1) current and past values of the actual inflation rate, (2) current and past rates of growth of the money supply, (3) budget deficits, (4) the cyclical state of the economy, and (5) supply shocks.[27] The finding that some or all of these variables are significant in these regressions implies that they are used in the formation of survey participants' expectations of inflation. The regression equations presented in Table III imply that the most important variables that the survey participants consider in forming expectations of inflation are the current and past values of the actual inflation rate and the current value of the money growth rate. The contribution made by money growth in explaining the formation of inflationary expectations is very impressive; both the $\bar{R}^2$ statistic and the standard error of the equation improve dramatically when money growth is introduced as an additional regressor in an equation containing only the past history of actual inflation (see equations 1 and 2 in Table III). Other variables including budget deficits (measured here by high employment government deficits), the gap between actual and potential GNP, and supply shocks do not help explain

[26] Several other economists have also examined the Livingston survey measure in an attempt to determine how expectations are formed. See Gordon (1979), Mullineaux (1980), Jacobs and Jones (1980), and Gramlich (1983). However, these authors have examined only the short-term forecasts of inflation (six-month). The focus of the present paper is on the twelve-month forecasts of inflation by the survey participants.

[27] See Gramlich (1983) for an explicit derivation of this equation.

Table III

EQUATIONS EXPLAINING EXPECTATIONS OF INFLATION OF THE LIVINGSTON SURVEY PARTICIPANTS, SEMIANNUAL DATA 1956.06-1983.12

Independent Variables	Dependent Variable: PE12 (1)	(2)	(3)	(4)
Constant		−.71	−.60	−.64
		(−2.8)	(−1.9)	(−1.9)
$\dot{P}_t$	.27	.51	.46	.48
	(3.8)	(10.9)	(8.1)	(7.4)
$\dot{P}_{t-1}$	−.02	.01	.04	.02
	(.3)	(.2)	(.7)	(.4)
$\dot{P}_{t-2}$	−.03	.10	.09	.09
	(−.5)	(2.2)	(1.9)	(1.8)
$\dot{M}_t$		.30	.31	.31
		(7.0)	(6.8)	(6.6)
HD_t				−3.2
				(−.4)
GAP_t				−.02
				(−.4)
SS_t			1.4	1.4
			(1.2)	(1.1)
$\bar{R}^2$	.34	.91	.87	.86
SER	.546	.445	.444	.451
DW	1.92	1.7	1.9	1.9
ρ	1.0	.5	.6	.6

Note: The general equation explaining the formation of expectations of inflation by the Livingston survey participants is of the form given below:

$$PE12_t = f(A(L)\dot{P}_t, B(L)\dot{M}_t, \dot{f}_t, CS_t, \dot{SS}_t)$$

where PE12 is the Livingston survey forecast made at time t of the annualized inflation rate over the 14-month horizon (t+14), $A(L)\dot{P}_t$ is the distributed lag on the past inflation rates known as of time t, $B(L)\dot{M}_t$ is the distributed lag on the past money growth rates, $\dot{f}$ is the change in the fiscal policy variable approximated here by the change in the high-employment government deficit scaled by nominal GNP (HD_t), $\dot{SS}$ is the change in the supply shock variable, and CS_t is a variable measuring the cyclical state of the economy —*approximated here by the averaged GAP measure* $((Y_t - Y^n)/(Y^n))$. Dummies for the wage-price and credit control periods were also added; they were generally insignificant. This equation and its various versions (equations (1) through (4)) are estimated with a first-order serial correlation correction procedure. The starting year for these regressions is 1956 because the data on the high-employment deficit is only available beginning that year. See footnote 29 for further details on the data. See also notes in Table IV.

this survey measure of expected inflation (see equations (3) and (4) in Table III).[28, 29]

If economic agents do consider money growth in forming expectations of inflation, is this relation stable between low-inflation and high-inflation periods? Table IV presents estimates of the expectation formation equation (equation 2 from Table III) for various subperiods obtained as a result of splitting as before the full sample periods. Rows 1 and 2 present estimates obtained for the low-inflation period and rows 3, 4, 5, and 6 present estimates obtained for the high-inflation period. For each subperiod, the coefficient on the money growth variable is positive and statistically significant. However, the point estimates of this coefficient obtained for the high-inflation period are substantially higher than those obtained for the low-inflation period (compare the coefficient on M_t in rows 1 through 6 in Table IV). This result could be interpreted to imply that the survey participants, in forming their expectations of inflation, give more weight to money growth when the average inflation rate is high. Furthermore, the size of the

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28 Several other measures, including the high employment government expenditure and the unemployment rate, were also tried. However, none of these variables entered significantly. In studies of the short-term inflation forecasts, Mullineaux (1980) and Gramlich (1983) also found that fiscal policy-related measures and the measures capturing the cyclical state of the economy (such as the unemployment rate, the GAP measure) did not help explain the formation of inflationary expectations.

29 The data used in these regressions are again semiannual observations corresponding to the Livingston survey data collected each June and December. The data on the (known) past values of actual inflation and money growth are generated using the monthly data on the consumer price index and M1. In constructing these actual inflation and money growth rates, it is assumed that the Livingston survey participants knew the April values for the CPI and M1 at the time of June survey and the October values at the time of December survey. The annualized growth rates were constructed by using the following formulas: the June growth rate = ((April Value in the Current Year/the February value in the previous year)$^{12/14}$−1); the December growth rate = ((the October value in the current year/the August value in the past year)$^{12/14}$−1). The quarterly data are used to construct the annual growth rates for variables measuring changes in the fiscal policy and supply shocks, and the first- and second-quarter observations are used in the regessions reported in Table III. The gap measure uses quarterly data on the real GNP and the natural real output; the latter are averaged over the preceding four quarters.

Table IV

ESTIMATES OF THE EFFECT OF MONEY GROWTH ON INFLATIONARY EXPECTATIONS OVER VARIOUS SAMPLE PERIODS, SEMIANNUAL DATA, THE LIVINGSTON SURVEY MEASURE PE12

	Coefficients On							
Sample Period	Constant	$\dot{P}_t$	$\dot{P}_{t-1}$	$\dot{P}_{t-2}$	$\dot{M}_t$	$\bar{R}^2$	SER	DW/ρ
1. 1952.06-1965.12	.91	.06 (.7)	−.12 (−1.8)	−.17 (−4.5)	.17 (2.6)	.46	.285	1.7/.8
2. 1952.06-1970.06		.07 (.9)	−.08 (−1.4)	−.14 (−3.6)	.09 (1.99)	.29	.322	1.6/1.0
3. 1966.06-1979.06	−.69 (−.9)	.53 (7.4)	.01 (.1)	.16 (2.1)	.24 (2.7)	.79	.522	1.8/.4
4. 1966.06-1983.12	−.81 (−1.3)	.52 (8.0)	.04 (.5)	.07 (1.2)	.32 (4.9)	.82	.506	1.9/.5
5. 1970.12-1979.06	−2.5 (−3.9)	.61 (11.7)	.00 (.05)	.17 (3.4)	.44 (6.1)	.96	.390	2.3/−.3
6. 1970.12-1983.12	−1.7 (−2.4)	.59 (10.4)	−.00 (−.00)	.07 (1.3)	.44 (6.4)	.93	.435	1.8/.2

Notes: The estimates for various subperiods reported here are of the regression equation (2) from Table III. This regression explains the formation of inflationary expectations mainly by current and past actual inflation and money growth rates. $\dot{P}_t$ is the actual yearly inflation rate known as of time t (June or December) the survey is made, $\dot{P}_{t-1}$, the lagged yearly inflation rate measured as of time t in the previous year, $\dot{P}_{t-2}$, the lagged yearly inflation rate measured again as of time t two years ago, and $\dot{M}_t$, the actual yearly money growth measured as of time t.

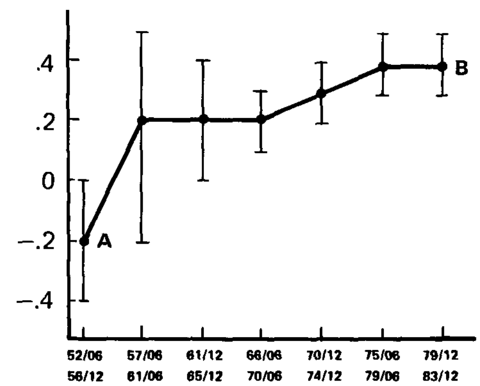
See footnote 29 for details on the way the growth rates are computed.

estimated coefficient on the first known value of the inflation rate in the equation also rises dramatically as one moves from the low-inflation period regressions to the high-inflation period regressions (compare the coefficient on P_t in rows 1 through 6 in Table IV). This probably suggests a relatively fast adjustment of inflationary expectations to current realized rates of inflation.[30]

Another way to examine the sensitivity of inflationary expectations to money growth is to estimate the time path of the coefficient on the money growth variable in the expectations formation equation. One simple way to do so is to estimate and plot the stabilogram for this coefficient. The stabilogram for any coefficient in a regression equation is simply a plot of the estimated coefficients and confidence intervals for various subperiods in a given sample. By choosing sufficiently short intervals and estimating the stabilogram, one can detect any change in the time path of the relevant coefficient by examining the time path of the stabilogram.[31] Figure 3 presents this stabilogram for the coefficient on the money growth variable in the expectation formation equation (2) from Table III. This plot clearly suggests that inflationary expectations proxied by the Livingston survey measure have become more sensitive to money growth over time.

Figure 3

STABILOGRAM ON THE MONEY GROWTH COEFFICIENT IN THE EXPECTATION FORMATION EQUATION 2, TABLE III SEMIANNUAL DATA: 1952/06–1983/12



The stabilogram on the money growth coefficient in the expectation formulation equation is constructed from the following equation.

$$PE12 = f\,(\text{constant}, \dot{P}_t, \dot{P}_{t-1}, \dot{P}_{t-2}, D1\dot{M}, D2\dot{M}, D3\dot{M}, D4\dot{M}, D5\dot{M}, D6\dot{M}, D7\dot{M})$$

where $D1\dot{M}$ is D1 times the money growth variable $\dot{M}_t$, $D2\dot{M}$ is D2 times the money growth variable $\dot{M}_t$, and so on. D1 through D7 are the dummy variables defined below:

D1 is one in 1952/06-1956/12 and zero otherwise,
D2 is one in 1957/06-1961/06 and zero otherwise,
D3 is one in 1961/12-1965/12 and zero otherwise,
D4 is one in 1966/06-1970/06 and zero otherwise,
D5 is one in 1970/12-1974/12 and zero otherwise,
D6 is one in 1975/06-1979/06 and zero otherwise,
D7 is one in 1979/12-1983/12 and zero otherwise.

The coefficients appearing on these dummy variables can be taken as the point estimates of the coefficient on the money growth variable for various subperiods; **AB** is simply formed by connecting these point estimates. The standard errors of the estimated coefficients on these dummies are then used to construct the confidence intervals indicated as vertical lines. The upper and lower limits of this confidence band are from the following relation: [Estimated Coefficient ± (2.0) (Estimated Standard Error of the Coefficient)].

IV.

A SUMMARY, MAIN CONCLUSIONS, AND SOME POLICY IMPLICATIONS

This paper has investigated the issue of whether a significant liquidity effect of money on interest rate exists. The recent empirical evidence on this issue has been mixed. One main problem with the current empirical work on this issue is the use of an inappropriate estimation procedure. The current empirical work usually investigates the existence of the liquidity effect by using OLS to estimate nominal interest rate regressions in which money growth appears as a right-hand side regressor. This procedure implicitly assumes that changes in money growth are exogenously determined and, in particular, are not contemporaneously correlated with the

[30] Mullineaux (1980) reports similar evidence for the short-term inflationary expectations. Using the varying parameter estimation technique, Mullineaux estimates the time path of the coefficients on the first known values of past inflation rate and money growth. He finds that there is a steady rise in the size of these coefficients over time (see Figure 1, p. 155).

[31] See Ashley (1984) for further details.

error term in these regressions. This is a questionable assumption to make in view of the way the Federal Reserve has conducted its monetary policy over the period 1952-1983. In particular, the shorter term monetary policy stance has been constrained by the Federal Reserve's concern to promote a stable financial environment and has had to be adapted to a variety of exogenous shocks. As a result, money growth is likely to be correlated with the error term in nominal interest rate regressions. The potential presence of this nonzero correlation implies that the ordinary least squares estimates of the parameter on the money growth variable are biased. Such statistical bias could generate an incorrect inference about the existence and the magnitude of the liquidity effect.

The approach taken in this paper is to specify a simple IS-LM-Aggregate Supply model of the economy and to estimate, using the instrumental variable estimation procedure, the implied nominal interest rate equation in which money growth is treated as an endogenously determined variable. The empirical results reported here imply the following conclusions.

First, there did exist a statistically significant liquidity effect in the '50s and the early '60s when the average inflation rate was very low. This liquidity effect, however, has now almost vanished. The coefficient on the money growth variable in the nominal interest rate regression is negative, large, and statistically significant when this equation is estimated over the subperiod beginning in the '50s and ending in the mid-'60s or the early '70s, but it is not significant when the same equation is estimated over the subperiod beginning in the mid-'60s or the '70s but ending in 1979 or 1983.

The second conclusion is that if the behavior of the Livingston survey participants is considered as representative of the behavior of other economic agents in the economy, this vanishing of the liquidity effect in the '70s is probably the result of increased responsiveness of inflationary expectations to higher money growth. An empirical analysis of the factors determining the Livingston survey inflation measure implies that these economic agents have over time paid more attention to money growth in forming their expectations of long-term inflation. This factor tends to reduce directly the magnitude of the liquidity effect associated with a given acceleration in money growth.

The results presented here have important implications for monetary theory and policy. An important issue in discussion of the transmission mechanism of monetary policy is the time pattern of the effects of higher money growth on nominal interest rates. The Keynesian view is that one would initially observe lower nominal and real interest rates following an acceleration in the money growth rate. The policy implication of this view is that the Federal Reserve could bring down interest rates and hold them there in the short run (at least for six to nine months) by accelerating the money growth rate. The results here, however, imply that the Keynesian view may now have to be modified. While nominal interest rates may still decline immediately following an acceleration in the money growth rate, this lowering of interest rates is shorter lived and less exploitable for policy purposes. In the '50s and the '60s, the Federal Reserve could induce falling nominal and real interest rates at least for six months by increasing the growth rate of the money supply. It now appears that its ability to do so has declined, mainly due to the increased responsiveness of inflationary expectations to higher money growth.

Finally, it should be pointed out that the public's perception of the way the Federal Reserve formulates and executes its monetary policy has considerable influence on the responsiveness of inflationary expectations to higher money growth. The upward drift in the growth rate of money which occurred in the '70s probably contributed to the higher inflation rate observed during that period. More recently, however, the United States has had considerable success in curbing inflation, and public confidence in monetary policy as a means of controlling inflationary expectations may have risen as a result. If so, we may observe yet another change in the response of inflationary expectations and nominal interest rates to higher money growth. To the extent such a change is already under way, the empirical results for the sample period ending in the year 1983 must be viewed with caution.

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