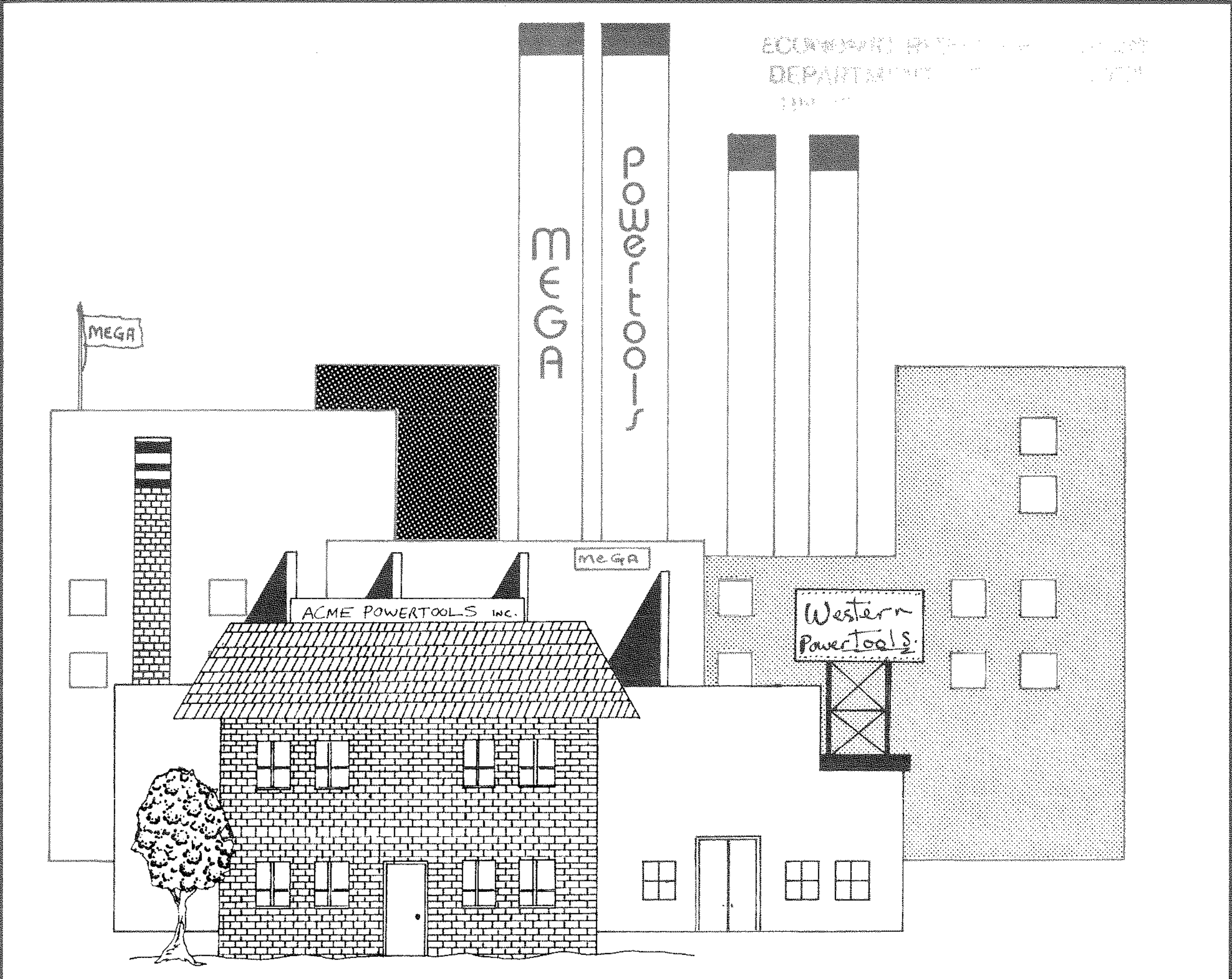
Federal Reserve Bank of San Francisco

Economic Review Number 1



Firm Size, Exchange Rates, and Interest Rates

Winter 1984

Dynamic Adjustment in Money Demand

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Models of money demand generally assume that in the short-run, actual real balances may diverge from their desired level. This paper compares two alternative explanations. The first is that the central bank fixes the nominal money stock but prices change slowly so that the real *money stock adjusts to its desired level with a lag. The second is that transactions costs cause individuals to change their nominal money holdings slowly. Empirical evidence mildly supports the second hypothesis, even during the 1979-82 period when the Federal Reserve closely monitored the nominal M1 stock.*

Models of money demand generally take it for granted that, in the short-run, the actual stock of real money balances may diverge from the "desired stock" determined by the prevailing levels of income and interest rates. The standard explanation for this divergence is that there are "transaction costs" to adjusting money holdings, which render it non-optimal for individual transactors to alter their stocks of money continually to hold them at desired levels. These transaction costs include not only such explicit charges as brokerage fees for buying and selling financial assets but also the psychological and "shoe-leather" costs of deciding upon and then implementing a change in average money holdings.

An alternative reason for expecting divergences between actual and desired real balances is that although individual transactors can increase or decrease their nominal money holdings, the economy as a whole cannot, as long as the central bank is controlling the stock of money closely. In other words, if the Federal Reserve fixes the nominal stock, money becomes a "hot potato", so that the desired stock of money must adjust to match the actual stock rather than conversely. As a result, divergences between the desired and actual stocks may occur not because economic agents are individually slow to adjust their actual money holdings to their desired levels but because the factors determining those desired holdings—prices, income and interest rates—do not adjust instantaneously to close such gaps.

The so-called "buffer-stock" approach to the demand for money in a sense lies between these two views of the adjustment process. According to this approach, an essential function of money is to serve as a "buffer" between streams of receipts and expenditures, both of which are somewhat unpredictable. The phrase "quantity of money demanded... does not refer to an amount of money which an (individual economic) agent will want to hold at each and every moment, but rather, to an amount which he will want to hold on average over some time interval."[1] The agent anticipates that his actual money holdings will vary around this average, rising when outlays are unexpectedly low or receipts are unexpectedly high, and falling when the converse is the case.

Indeed, it is largely because agents anticipate such variations (that is, they expect the unexpected) that they hold stocks of money.[2] As a result, when money holdings *do* rise or fall, agents do not immediately seek to move their holdings back to their desired average level. This explains why—even at the level of the individual agent—"actual" money may diverge from "desired"money, and also why the factors determining the total desired

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stock—income, prices and interest rates—do not adjust rapidly to eliminate such divergences.

In a recent article in this *Review*, Judd and Scadding compared a variety of alternative dynamic models of money demand.[3] They concluded that models in which divergences between desired and actual real balances resulted from slow adjustment in *prices* provided the best explanation of U.S. data. Judd and Scadding used quarterly data and their estimation period ended in 1974. The purpose of this short paper is to compare the performance of this "price-adjustment" model with the conventional approach using monthly data over the period since mid-1976 and, in particular, to examine whether changes in the central bank's policy target have affected the results of this comparison.

The use of monthly data raises the issue of whether the "adjusting variable" may be different according to the length of time considered. Most theoretical models assume that, in the short run, income and prices are essentially fixed and that it is the interest rate that moves to equate money supply and money demand. Interest rate changes are then transmitted to income and prices over a longer time period. Judd and Scadding found that a model in which interest rates move in response to divergences between money supply and money demand was unable to explain U.S. quarterly data. A possible explanation for their result would be that the interest rate adjustment process is completed within a quarter and so cannot be captured in quarterly data.

However, in preliminary tests, I obtained similarly poor results using monthly data, casting some doubt on the standard view that interest rates are the adjusting variable in the short run. In view of these initial results, I decided to limit this study to a comparison between the conventional money-adjustment approach, in which the *nominal* money supply adjusts to the public's demand for *nominal* money balances, and the price-adjustment approach in which the nominal supply of money is fixed and prices adjust to equate the *real* money supply with the public's demand for *real* money balances.

Alternative Models of Dynamic Adjustment

The *price adjustment model* begins with the assumption that prices change in response to the difference between the actual money stock determined by the central bank and the desired stock:

$$\Delta P_t = \gamma[M_t - (m_t^d + P_{t-1})] \qquad (1)$$

where all variables are in logarithms and m_t^d represents the desired stock of real balances given the levels of real income, y_t, and interest rates, i_t,

$$m_t^d = a_0 + a_1 y_t + a_2 i_t \qquad (2)$$

Substituting Equation (2) into Equation (1) and adding an error term yields

$$P_t = (1\text{-}\gamma)\, P_{t-1} + \gamma M_t \\ - \gamma a_0 - \gamma a_1 y_t - \gamma a_2 i_t + u_t^P \qquad (3)$$

This equation also may be written in an alternative form:

$$M_t - P_t = (1-\gamma)(M_t - P_{t-1}) \\ + \gamma a_0 + \gamma a_1 y_t + \gamma a_2 i_t - u_t^P \quad (3a)$$

The Judd-Scadding version of the *money adjustment model* begins with the assumption that the nominal money stock responds to the difference between the currently desired money stock and the actual stock in the preceding period, after adjustment for the effect on the actual stock of the change in bank loans:

$$\Delta M_t = \delta \Delta BL_t \\ + \lambda[m_t^d + P_t - (M_{t-1} + \delta \Delta BL_t)] \qquad (4)$$

Substituting Equation (2) into Equation (4) and adding an error term yields

$$M_t = (1-\lambda)M_{t-1} - \lambda P_t + \delta(1-\lambda)\Delta BL_t \\ + \lambda a_0 + \lambda a_1 y_t + \lambda a_2 i_t + u^M_t \qquad (5)$$

As in the case of the price-adjustment model, this equation also may be written in an alternative form:

$$(M_t - P_t) = (1-\lambda)(M_{t-1} - P_t) + \delta(1-\lambda)\Delta BL_t \\ + \lambda a_0 + \lambda a_1 y_t + \lambda a_2 i_t + u^M_t \qquad (5a)$$

It is important to note that in Equation (3) the price level is the dependent variable and the nominal money stock is exogenous, whereas in Equation (5) nominal money is endogenous and prices are exogenous. Although the models may be transformed algebraically to *appear* to have the same dependent variable, such transformations do not alter the estimated parameters as long as the appropriate coefficient restrictions are imposed. In comparing the models, it is important to bear this in mind, since the variance of prices is substantially less than the variance of the nominal money stock.[4]

Empirical Results

The results of estimating Equations (3a) and (5a) over the period 1976.08-1983.08 are shown in Table 1. The entries represent the underlying structural parameters of the models: the long-run elasticities with respect to real income and the interest rate [a_1 and a_2 in Equation (2)] and the adjustment coefficients (λ and γ). It is striking that the elasticity estimates are extremely close. Moreover, both the income elasticity (not significantly different from unity) and the interest rate elasticity are close to estimates made with the San Francisco Money Market Model.[5]

The standard error of the price-adjustment equation is noticeably lower than that of the money-adjustment model. This result is the same as that reached by Judd and Scadding using quarterly data over an earlier sample period. However, this finding does *not* necessarily imply that the price-adjustment model is superior because the variance of the dependent variable also is lower in the price-adjustment equation. In terms of the proportion of total variance explained, the models are quite similar and, in fact, the money-adjustment model provides a slightly better fit. Allowing for degrees of freedom, the price model explains 28.5 percent of total variance while the money model explains 34.4 percent.[6]

Table 1
Money Demand Equations (1976.08—1983.08)

	Price Adjustment Model	Money Adjustment Model
Adjustment Factor*	0.038	0.109
	(2.760)	(3.768)
Real Personal Income	1.110	1.018
(Elasticity)	(2.635)	(3.958)
Commercial Paper Rate	-0.194	-0.182
(Elasticity)	(3.221)	(4.645)
Change in		0.276
Bank Loans**		(2.070)
Constant	-2.872	-2.021
(Long Run Value)	(0.927)	(1.087)
RHO 1	0.247	0.186
	(2.207)	(1.523)
RHO 2	-0.020	-0.177
	(0.183)	(1.453)
SEE	0.002095	0.004504
"Explained" Sum of Squares***	0.285	0.344

* γ in Equation (3); λ in Equation (5)
** δ in Equation (5)
*** Based on monthly growth rates of prices and nominal money, and adjusted for degrees of freedom. See footnote 6.

The underlying theory of these models suggests that their appropriateness should depend on the monetary policy rule being followed by the central bank. If, for example, the authorities pursue an interest rate target in the short run, the stock of nominal money is endogenous and hence the money-adjustment model is appropriate. With a money-stock target, on the other hand, money becomes a "hot-potato," making the price-adjustment model more appropriate.

To test the idea that the policy rule may influence the adjustment mechanism, the full sample period (1976.08-1983.08) was divided into two subsamples. In 1979.10-1982.07, the Federal Reserve was assumed to be fixing the nominal money stock in the short run; hence the price adjustment model should be the appropriate one. In 1976.08-1979.09 and 1982.08-1983.08, the Federal Reserve was assumed to be allowing the nominal money stock to be endogenous in the short run; hence the money-adjustment model should be appropriate. Separate equations were estimated for these two periods. The results are shown in Table 2. The coefficients shown in the first and second columns of the table are unconstrained estimates, while those in the third and fourth columns were made subject to the restriction that the underlying long-run income and interest rate elasticities remained constant over the full 1976-83 sample period. This restriction reflects the assumption that these long-run elasticities do not depend on the policy regime. Under this restriction, the estimated elasticities are not much different from those estimated in Table 1.

The results in Table 2 cast some doubt on the price-adjustment model. When this model is estimated over the period for which theory suggests it should be most appropriate (the period from October 1979 to July 1982, during which the Federal Reserve was targeting M1), the income and interest rate elasticities are implausibly low. These elasticity estimates change dramatically when the constraint that they are constant over the full 1976-83 period is imposed[7] [compare columns (1) and (3) of the table]. By contrast, the money equation yields plausible parameters that do not change much when the restriction is imposed.

I would interpret these results as giving some support to the money-adjustment model and casting some doubt on the price-adjustment model, but the evidence is not strong either way. One possible explanation for the results is that although the Federal Reserve *targeted* M1 over the 1979-82 period, it did not control it sufficiently closely in the short run for it to be genuinely exogenous. Even over this period, then, M1 was not a true "hot potato." Another explanation could be that the sample period for the price-adjustment model is short and includes highly unusual interest rate and income volatility as well as a period of credit controls.

Summary and Conclusions

The principal purpose of this paper was to reexamine the question raised by Judd and Scadding as to the appropriateness of the conventional assumption in money demand studies that nominal money demand responds to changes in its determinants (income, prices, interest rates) with a lag. The alternative view considered here is that the real money supply adjusts to real demand with a lag because prices adjust slowly. Judd and Scadding concluded that the price-adjustment model outperformed the money-adjustment specification.

I have argued that the appropriate specification, in principle, depends on the policy regime in effect. If the central bank is pursuing a nominal M1 target, money becomes a "hot potato" and the conventional specification in which nominal money is the adjusting variable will not be appropriate. Such a specification would be suitable if the Federal Reserve had an interest rate or nominal income target and, in the short run, allowed the nominal supply of money to adjust in response to changes in demand.

I also argue that it is not appropriate to compare these models in terms of the standard errors of the estimated equations under the rival specifications. Under the conventional specification, the dependent variable is the nominal money stock, whereas under the alternative, the dependent variable is the price level. Since the variance of prices is less than that of nominal money, one expects an equation with prices as the dependent variable to have a lower standard error. The models cannot be rearranged to have the same dependent variable, so

Table 2
Money Demand under Varying Policy Regimes

	Unconstrained Price Adjustment Model (79.10-82.07)	Unconstrained Money Adjustment Model (76.08-79.09, 82.08-83.08)	Constrained Price Adjustment Model (79.10-82.07)	Constrained Money Adjustment Model (76.08-79.09, 82.08-83.08)
Price Adjustment Coefficient	0.0953 (1.925)		0.0236 (1.197)	
Money Adjustment Coefficient		0.0707 (4.50)		0.0739 (4.65)
Real Personal Income (Elasticity)	0.353 (1.41)	1.155 (9.68)	1.096 (11.70)	1.096 (11.70)
Commercial Paper Rate (Elasticity)	- 0.006 (1.41)	- 0.182 (7.54)	- 0.171 (8.24)	- 0.171 (8.24)
Change in Bank Loans[1]		0.184 (1.35)		0.192 (1.38)
Constant	2.871 (1.62)	- 2.93 (3.39)	- 2.837 (3.85)	- 2.503 (3.68)
RHO1	0.230	- 0.338	0.256	- 0.331
RHO2	0.180	- 0.257	0.182	- 0.249
SEE[2]	0.003053		0.003087	

1. δ in Equation (5)
2. These standard errors refer to the full sample period and measure the ability of the combined models to explain the data.

that it is not possible to set up a "nested" equation that includes each model as a special case.

There is some weak evidence that the money-adjustment specification provides a superior explanation of the U.S. experience. The estimated parameters appear to be more stable under this specification. On the other hand, the empirical results suggest that the estimates of the underlying long-run parameters are not sensitive to the dynamic structure chosen. This is a very useful result since it implies that, at least in the long-run, predictions of the effects of changes in the stock of nominal money on income, prices and interest rates will not be affected much by the adjustment assumptions made in estimating the money-demand relation.

FOOTNOTES

1. David Laidler, "The Buffer Stock Notion in Monetary Economics," 1983 Harry Johnson Lecture, April 12, 1983.

2. The fact that agents hold this buffer in the form of money rather than of other assets which yield interest is explained by the existence of transactions costs of switching between money and these other assets.

3. John P. Judd and John L. Scadding, "Dynamic Adjustment in the Demand for Money: Tests of Alternative Hypotheses," *Economic Review*, Federal Reserve Bank of San Francisco, (Fall 1982).

4. The variance of the monthly change in the logarithm of prices (i.e. the monthly growth rate) over the period from August 1976 to August 1983 is 6.30×10^{-6} whereas that of the monthly change in the logarithm of nominal money is $3.17 \times 10.^{-5}$ Thus nominal money was approximately five times more variable than was the price level.

5. John P. Judd, "A Monthly Model of the Money and Bank Loan Markets" Working Papers in Applied Economic Theory and Econometrics, No. 83-01, May 1983.

6. For each equation this proportion is computed as

$$1-[(RSS/n-k)/(TSS/n-1)]$$

where n is the number of observations, k is the number of parameters estimated, RSS is the residual sum of squares of each equation and TSS is the total sum of squares of the monthly growth rate of the dependent variable in each equation (i.e., prices and nominal money respectively).

7. An F-test of this restriction cannot reject it at the 5% level of significance. The computed F-statistic is 1.72, compared to a critical value of 3.13.