FRBSF Weekly Letter

Number 95-05, February 3, 1995

What Are the Lags in Monetary Policy?

The economist's adage about monetary policy actions is that they affect the economy with "long and variable" lags. This *Letter* considers some empirical evidence on how long and how variable those lags may have been in the past. To the extent that past effects will be similar to those today, such estimates may shed light on the magnitude and timing of the effects of the tightening of monetary policy last year.

This *Letter* reviews empirical estimates from four models that are based on particular theoretical structures of the economy; in addition, I examine estimates from a purely statistical model. All of these estimates use movements in short-term interest rates to identify the stance of monetary policy. Such an identification is now widely accepted (for example, see any of the references cited below), in part, because recent financial innovation has reduced the reliability of traditional measures of the money supply to indicate policy actions.

Overall, all the models appear to provide fairly consistent evidence that a monetary tightening or loosening has the greatest effect on the growth of output during the first eight quarters, and that this effect is fairly evenly distributed between the first and second years. Nevertheless, it should be stressed that there is substantial uncertainty associated with the models' estimates of the dynamic response of output to any particular monetary policy episode.

Structural model estimates

An estimate of the effect of a monetary policy action on output can be easily obtained from a structural macroeconometric model. Simply measure the difference between two dynamic simulations of the model—one with and one without the policy action. This section examines the responses of four different structural models: (1) the MPS model, which is maintained by the staff of the Federal Reserve Board (see Mauskopf 1990); (2) the DRI model, which is a commercially available product (see Probyn and Cole 1994); (3) the FAIR model, which is maintained at Yale University by Ray Fair (see Fair 1994); and (4) an FRBSF model, which was developed at this Bank.

These four models vary considerably in size, ranging from about 30 stochastic equations in the FRBSF and FAIR models to almost 1,000 equations in the DRI model. However, all of the models specify the structure of the economy in fairly similar traditional Keynesian terms. In each model, the short-term interest rates most closely associated with monetary policy actions are linked to long-term interest rates via a backward-looking term structure equation. Thus, changes in short rates are assumed to change expectations about future short rates only gradually; hence, short rate changes become embedded with a lag in long rate. These changes in long and short nominal interest rates generally imply changes in real rates as well, because wage and price expectations are assumed to adjust only sluggishly. These interest rate movements also affect household financial wealth in the models because of an arbitrage among bond, equity, and other asset prices. In addition, for two of the models—MPS and DRI—the foreign exchange rate also responds to interest rate movements.

In the models, these financial market repercussions of monetary policy actions affect all categories of real economic activity. Typically, inventory investment is linked most closely to short rates, business fixed investment and residential construction are linked to long rates, household spending on durable goods depends on financial wealth as well as interest rates, and net exports are tied to the exchange rate. However, the response of production and real spending to the changes in the financial environment is modeled with a lag that reflects, for example, the delay from new spending plans to new orders and contracts and finally to new construction and production. The length of this lag varies with the category of spending but is typically at least several quarters in duration.

The first four lines of the table display the lagged monetary policy responses of output in the structural models. The fifth line gives the average

Table 1
The Effect on GDP Growth of a 1 Percentage Point Increase in Short-Term Interest Rates
(In Percentage Points)

	1st year	2nd year	3rd year
Structural Models			
MPS	−.20	−.70	−1.10
DRI	−.47	−.53	−.13
FAIR	−.24	−.25	+.03
FRBSF	−.55	−.19	+.04
Average	−.37	−.42	−.29
Nonstructural Model			
VAR	−.64	−.26	+.08

response. Each line shows the estimated effect on the four-quarter growth rates of output during each of the first three years after a 1 percentage point increase in short-term interest rates.

Overall, the responses of the models to a monetary shock are fairly similar during the first eight quarters. Averaging across the models, the 1 percentage point increase in the short rate slows output growth by about four-tenths of a percentage point in each of the succeeding two years. Thus, two years after a tightening, the level of real GDP is about three-quarters of a percent lower than it would have been otherwise. The average effect of a monetary shock on the growth of output for these models is greatest during the first eight quarters. However, the models do differ significantly in describing the effect of a monetary shock past two years, with the MPS model showing a further significant reduction in the growth of output and the other models showing little further response.

Nonstructural model estimates
In the last decade, most empirical research on the dynamic response of output to monetary policy has eschewed structural models. Instead, researchers have investigated the effects of policy using vector autoregressions (VARs), which are small, purely statistical models. These VARs typically contain no more than half a dozen variables and are constructed simply by regressing each variable, in turn, on all of the other variables. The VARs contain essentially no theoretical economic structure, and, in particular, they take no stand on the nature of a monetary transmission mechanism. However, VARs are particularly adept at summarizing the dynamic correlations found in the data; hence, they can provide useful information on the response of output to movements in interest rates. (For an introduction and references to the literature, see Balke and Emery 1994.)

The bottom row in the table gives the response of output to a tightening of monetary policy as estimated from a VAR. (The VAR used is fairly typical of those in the literature and contains four variables: real GDP, the GDP deflator, a commodity price index, and the federal funds rate.) A 1 percentage point positive shock to short-term interest rates shaves about six-tenths of a percentage point off the growth of GDP in the first year after the shock and another quarter of a percentage point in the second year. The VAR's overall response is broadly in line with the estimates from the structural models; however, in the VAR, the bulk of the impact on output growth occurs a bit earlier than for the structural models.

Uncertainty about the estimates
The imprecision associated with the above numerical estimates should not be underestimated. Uncertainty about the effect of policy arises because the specification of the model is not known to be correct. At the very least, there is uncertainty about the appropriate variables to be included in the model as well as the appropriate values of the parameters in the equations of the model.

For example, to appreciate the degree of uncertainty surrounding the estimates in the table, we can begin by considering the uncertainty in the models' parameter estimates. Taking into account such model uncertainty for the VAR, a 90 percent confidence interval for the effect of the policy shock on output growth during the first four quarters is about half a percentage point in size and ranges from −0.9 to −0.4 of a percentage point. In the second and third years after the policy action, the ranges are even larger—about six-tenths of a percentage point in size. Similar confidence intervals incorporating parameter uncertainty are harder to obtain for the structural models' estimates. However, based on a related investigation in Fair (1994), it appears likely that such estimates also are plagued by about the same amount of imprecision from parameter uncertainty.

Assessing the effects of other types of model misspecification is more difficult. For the structural models, some of this uncertainty can be gauged from the range of estimates presented in the table. For example, in the second year after the increase in interest rates, the four models give a range of estimates of the effect on output growth of about one-half of a percentage point in size. Given that these models share a similar intellectual framework, this range should be viewed as just a starting point regarding the effect of structural uncertainty.

For the VAR, one area of structural uncertainty involves the number of lags of variables to be included in the equations. The VAR in the analysis above used six lags. Letting the number of lags vary from four to eight, the 90 percent confidence interval for the second-year effect on growth is boosted in size to about eight-tenths of a percentage point (including parameter uncertainty), while the first- and third-year confidence intervals are little affected. However, some modest experimentation suggests that all of the confidence intervals would be enlarged by varying the variables included or the estimation sample period.

The lags in recent policy

The level of short-term interest rates rose by about 2½ percentage points during 1994 as a result of a monetary tightening. This increase was fairly evenly distributed over the year. Can the above results aid in assessing the timing of the effects of these policy actions? Taken at face value and ignoring their imprecision, the model estimates suggest that as a rough average approximation, over half of the total effect of the increase in rates will be felt in 1995, with the residual impact fairly evenly distributed in 1994 and 1996. However, several important caveats are in order.

For the structural models, the applicability of the results depends crucially on the validity of the models' specifications. However, these models may not be accurate guides to judging the timing of the effects of the most recent policy tightening. Perhaps the most significant departure of recent history from the models is in bond yields. The term structure equations in the structural models, which imply that long-term rates react with a lag to changes in the short rate, are an important element in the models' lagged output responses. In contrast, during the past year, the actual increases in short rates have been matched contemporaneously and, at times, even have been anticipated by equivalent increases in long rates. This deviation from the models suggests caution in relying on the structural model estimates.

For the VAR, there is a more subtle caveat. The VAR output effects shown in the table are in response to a positive *innovation* in interest rates, which is defined as an (exogenous) change in rates that is not in response to changes in any other variable. An endogenous change in interest rates, that is, one which is typical of past changes and is predictable, might well be followed by an output path that was much different from the one given in the table. Thus, any assessment of the effect of recent policy on output with a VAR requires a decomposition of recent interest rate increases into exogenous and endogenous changes. Such decompositions are model-dependent and are likely to be contentious.

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References

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