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Uncertainty in the Monetary Aggregates: Sources, Measurement and Policy Effects*

DAVID A. PIERCE,** DARREL W. PARKE,** WILLIAM P. CLEVELAND,** and AGUSTIN MARAVALL†

I. Introduction

FOR A VARIETY of reasons observed data on the monetary aggregates are subject to uncertainty or error. In some instances first published data are revised at a later date due to errors in preliminary data which can be observed and corrected; in others the error persists in the final data. Cutting across this classification are the numerous sources of error, including definitional error, transitory error, seasonal adjustment error, sampling, clerical or reporting error, etc.

This survey paper deals with the sources and, where possible, magnitudes of uncertainties in monetary series. The next three sections discuss conceptual and definitional issues and the current procedures for assembling the money supply data. Sections 5 through 7 then consider, respectively, uncertainty due to sampling and reporting, transitory variation, and seasonal adjustment. Some implications, including possible consequences for monetary policy and the effects on relationships to other series, are assessed in Sections 8 and 9, and the concluding section presents some suggestions for dealing with errors in the aggregates.

II. Conceptual Issues

The variation in an observed series generally has several sources. The contributions of each may be formalized as components of an overall model. Each component is, in a sense, an unobservable construct. When the model for a component is identified, the component will have a unique estimate for a given data set. When agreement on a model is lacking, as in seasonal adjustment, there are many possible definitions of the construct available. In these situations a range of answers is possible in addition to statistical variation in each answer. Since component estimates are interrelated, a change in the specification of one component may affect estimates of another.

III. Definitional Error

There are several measured versions of the money supply, M-1a, M-1b, M-2, and so forth. There are also several points from which money is viewed: as a store of

* Any views expressed are the authors' and not necessarily related to those of the Federal Reserve System or the Bank of Spain.

** Federal Reserve Board, Washington, D.C.

† Bank of Spain.

value, medium of exchange, index of liquidity, among others. Some analysts attempt to use the money supply to forecast values of such variables as prices and national income, while others use the money supply to guess what will be the reaction of the Federal Reserve to it (e.g., forecast interest rates). No single series can satisfy everyone's purposes. The difference between the measured money supply and a user's notion of what it means is what we call definitional error. The size of the definitional error is particular to the user, although the money stock could be constructed in ways designed to measure more nearly what certain users are interested in. For example, Barnett, Spindt and Offenbacher [1980] propose such a measure.

IV. Estimation of the Money Supply

The published money supply consists of the net liabilities to the public of the Federal Reserve and depository institutions. Each week the 5,500 banks that are members of the Federal Reserve System report their daily closing balances. Samples of nonmember banks and the other institutions also report similar information each week.[1] Using these data, weekly estimates of the money stock are calculated and published nine days later. They are revised one week after that to account for data from late reporters and corrections of various reporting and processing errors.

Each quarter, balance sheets are obtained from all 8,700 nonmember banks. The sample-based estimates are then revised to incorporate this new information. Similar "benchmark revisions" are made for the other financial institutions. A third revision occurs at the beginning of each year when a revised seasonally adjusted series and the seasonal factors to be used during the coming year are published.

The effects of these revisions on month-to-month growth rates of M-2 were studied by Bach et al. [1976]. They found that the standard deviation of the difference between the first published annualized growth rate (made about 10 days after the end of the month) and the first revised estimate (made about 20 days later) was 1.25 percentage points; the standard deviation of the difference between the final (benchmarked and re-estimated seasonals) estimates and the first published growth rates was about 3.2 percentage points; and that about 2.1 percentage points of the latter standard deviation was due to revisions in the seasonal factors.

V. Sampling, Reporting, and Processing Error

For illustrative purposes, we concentrate on one component of the money supply—demand deposits at commercial banks. As noted in the preceding section, the 5,500 member banks and a sample of 600 nonmember banks report deposit balances each week. The current week's commercial bank demand deposits are the sum of deposits reported by member banks and estimated deposits at nonmember banks. The former differs from actual demand deposits at member

[1] This situation will change in the fall of 1980 when nearly all financial institutions will begin reporting each week.

banks because of reporting and processing errors, while the latter differs from actual deposits at nonmember banks because it is based on only a sample of banks and because of reporting and processing errors in the sample data. The *sampling* standard error can be reduced by increasing the nonmember bank sample size. However, such a step can increase the reporting and processing error if the larger sample cannot be as intensely edited as can the smaller sample. The estimation of these trade-offs is a matter for further research.

Sampling error is reduced substantially by moving from weekly to monthly estimates. The nonmember bank sample estimates of weekly-average demand deposits, for example, have an estimated sampling standard error of about $520 million (about .15 percent of M-1). The estimated standard error of a monthly average is about 37 percent lower. The corresponding reduction in the (unknown) standard deviation of reporting error is likely to be of similar size.

VI. Transitory Error

Over time the money stock is subject to very short run variations that bear little, if any, relation to the economy. For example, if a government check on its way to a bank is delayed at the post office for a day, the measured money stock will be lower on that day than it would otherwise have been. These kinds of variations are called transitory because they are fleeting in nature and provide no information about the underlying economic process.

Most operational definitions of transitory error have centered around a statistical (or economic) model for the "systematic" part of the series, the transitory error being the model's residual. For example, one could regard as transitory that part of a signal-plus-noise decomposition of a series which is serially uncorrelated. However, it is important to note that there may still be some other series with which this transitory component is related, so that the transitory variance could be reduced relative to a larger information set.

The uncertainties in model specification and the resulting ranges of estimates of transitory error variances for the monetary aggregates are illustrated by a series of studies in Porter et al. [1978]. Both daily and weekly data on M-1 were used, and alternative specifications for the trend were employed. The resulting estimated transitory standard deviations ranged from about 0.1% to 0.25%, when stated in terms of monthly data.

Finally, it should be noted that transitory error in the historical series is partially eliminated by the seasonal adjustment procedure. A positive transitory component one month, for example, tends to increase the seasonal factor for that month and thereby decrease the seasonally adjusted value.[2]

VII. Seasonal Adjustment Error

Seasonal factors suffer from three problems. They have no precise definition, their estimates can be adversely affected by inadequate treatment of other components, and their final estimates usually require future data.

[2] See Pierce [1980] for further detail on the negative correlation between seasonal adjustment error and transitory error.

Science is coming to seasonal adjustment, but this subject remains largely an art at the moment. The most frequent definition of a seasonal factor is whatever the X-11 program using default options produces after three to five years of future data are in. This is allowing a computer program to make the artistic decisions. When the results of various options are examined and a procedure selected, the analyst makes decisions according to his artistic criteria. This may include special treatment of certain data values. Model-based approaches bring some science to bear on the problem, but an identification problem remains (see Sec. 7.2).

A current observation x_t is generally expressed as the sum of three components—one due to trends and business cycles, one incorporating the seasonal behavior, and an irregular component which includes sampling error, transitory error, and reporting errors. Under the assumptions that these components are mutually independent and that each is generated by known stationary or homogeneously nonstationary stochastic processes, the minimum mean square error estimate of the seasonal component is a symmetric moving average of x_t with weights depending on these processes or models. The resulting mean square error may also be determined from these models.

In practice, most economic data are seasonally adjusted using the X-11 procedure (Shiskin, Young and Musgrave, [1967]), which also uses a symmetric moving average along with some adjustments for outliers and other effects. The seasonal adjustment error from X-11 has usually been viewed as the result of this moving average applied to the sampling error of x_t. However, using the approximate model for X-11 in Cleveland [1972], an alternative estimate of the variance of the seasonal adjustment error from X-11 can be obtained. For the U.S. money supply (old M-1), measured monthly, the standard deviation of this error is about .09 of one percent (of the level of the series).

7.1 Revisions Due to Seasonal Adjustment

The seasonal adjustment procedures described above make use of data both prior and subsequent to the datum being adjusted, as both future and past observations contain information pertinent to seasonality at a given point in the series. Thus, for the seasonal adjustment of current or recent data and for forecasting seasonal factors, preliminary estimates of the seasonal factors are made, which are subsequently *revised* as more values are observed. Insofar as the historical seasonal adjustment is, or better approximates, what is desired, these revisions represent error in the first-published aggregates.

For the U.S. money supply (old M-1) it was found that the mean square revision in first published data over 1974–77 was 0.18%, with little variation between months of the year. Since revision errors and final SA errors are uncorrelated, one obtains a standard deviation of .20% for the total error in M-1 due to seasonal adjustment. For example, if a preliminary seasonal factor of .955, the true value would be less than .953 or over .957 almost one-third of the time, simply due to uncertainty in seasonal adjustment.

7.2 *Alternative Specifications*

Different seasonal adjustment procedures may lead to different estimates of seasonal factors. Even a given model for an observed series does not provide a unique determination of the seasonal. At issue primarily is how much noise will be allowed to get into the seasonal factors in order to permit a varying seasonal pattern. Two model based adjustments were performed, each using the same model for the observable demand deposit series. The root mean square difference between the minimum variance estimate and the other was over 1%, while the root mean square difference from the X-11 result was .5%. These numbers compare with a revision error of .18% for X-11 itself and illustrate the magnitude of the identification problem for seasonal components or factors.

7.3 *Policy Seasonal*

Until about a year ago, the Fed attempted to determine what interest rate would be consistent with a desired rate of growth of the money stock. Since there has been virtually no seasonal pattern in interest rates, seasonal patterns in the demand for money have been reflected in the seasonal patterns in the quantity of money. In particular, shifts in the seasonal pattern of money demand can be detected by observing the shifting seasonal in the money stock.

In October, 1979 the Fed changed its method of operation so that it now attempts to control the supply of seasonally adjusted money by holding reserves at a level consistent with the desired level of money. Assuming seasonal factors continue to be estimated as they have been in the past, shifts in the seasonal pattern of money demand will no longer be reflected in the seasonal pattern of the money stock. That is, the observed patterns will be to a greater degree the result of Fed policy (supply) and less exclusively as result of the public's demand.[3]

VIII. Effects of Error on Possible Monetary Policy Actions

In the preceding sections, we have described the major sources of uncertainty in the monetary aggregates. We now consider effects of uncertainty on the implementation of monetary policy. This section, taken from Maravall and Pierce [1980], examines the danger that, because of error or uncertainty, the monetary authority will misjudge an incoming money supply figure and thereby take inappropriate action, or fail to take appropriate action. Attention is confined to the effects of observable error or revisions, which can be measured empirically. The added presence of unobservable error would increase still further the effects on policy of the uncertainty which we do measure.

At each monthly meeting the Federal Open Market Committee sets a target range for the rate of growth of the monetary aggregates over a two-month period.

[3] Some have contended that there has always been a policy seasonal; for example, Bach, et al. [1976].

Policy action depends (among other things[4]) on whether or not the growth of the aggregates falls within this range (see, e.g., Wallich and Kier [1978] for further discussion). Of necessity, however, policy is made on an ongoing basis, when only preliminary data are available. Therefore, the policymaker is confined to observing whether the *preliminary* growth rate, calculated from data containing errors not yet observed (from updating seasonal factors, benchmarking for nonmember banks, and other sources) lies within this range of tolerance. The question we address is thus the frequency with which the preliminary and revised growth rates give conflicting signals as a result of one figure lying inside and the other outside (or one above and the other below) the range of tolerance. Insofar as this range is intended to be for "true" M-1 growth rates, or at least the reported final rates, policy actions taken on the basis of such signals may be regarded as mistakes, caused by errors in the money supply data.

Figure 1 shows, for the 1974–77 period, the FOMC range of tolerance for the M-1 growth rate, and the preliminary and final versions of that rate, m_t^o and m_t^f respectively. Over this period, the proportion of times a "mistake" would be made (by relying on m_t^o rather than m_t^f) is 21/48 or 44%. While it is not possible to decompose this figure (44%) into amounts due to seasonal and nonseasonal revisions separately, Maravall and Pierce [1980] show that error in preliminary seasonal factors has dominated other types of preliminary-data error in causing uncertainty in monetary aggregate targeting.

Moreover, we note that m_t^f is itself inside the tolerance interval more often than is m_t^o. This event could simply reflect the higher degree of noise in preliminary data, and the monetary authority's awareness of this noise in conducting policy. For example, smoothing current data by seasonally adjusting on a *concurrent* basis each month results in preliminary growth rates which may more accurately predict the final figures.

IX. Uncertainty in Relations Between Monetary Aggregates and Other Variables

Thus far we have examined sources of error and uncertainty in the aggregates themselves and the resultant effects on the implementation of monetary policy: *Given* a targeted path for an aggregate series, how does error in that series render it difficult to maintain that path? But this path is itself chosen to achieve a desired performance in other variables of importance, such as inflation, output or employment. Thus an equally important concern is the uncertainty or error in the relationships between the monetary aggregates and these variables (caused in no small measure by errors of sampling, seasonal adjustment, etc., which we have discussed).

But such enquiry is fraught with uncertainty and error. Several recent investigations have demonstrated the lack of "firm" empirical relationships between

[4] More precisely, policy action depends on whether a *forecasted* aggregate (conditional on taking no action) falls within the range for the current two-month period. Since data on forecasts are unavailable, we use actual figures instead, noting that in any event the actual figures' behavior would ordinarily exert the dominant influence on the subsequent forecasts.

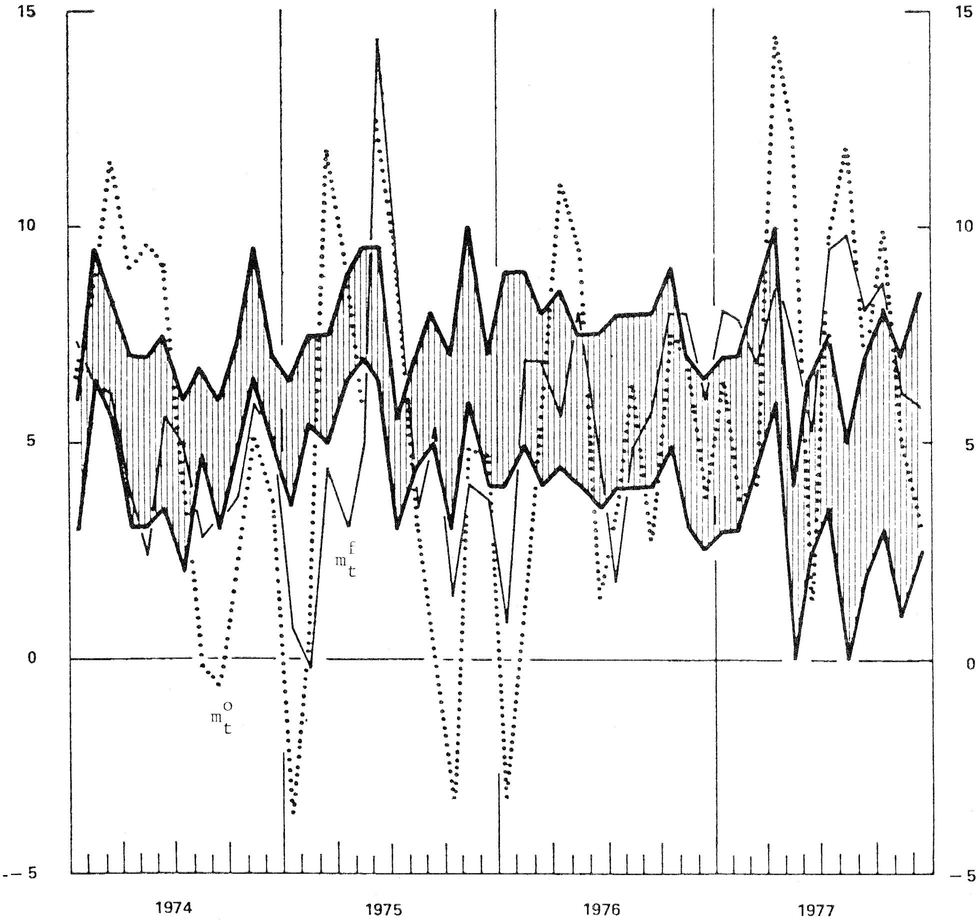

Figure 1
M-1 Tolerance Region (shaded) in Relation to Preliminary and Final M-1 Growth Rates

important economic time series, in the sense that alternative and incompatible model specifications, can each produce comparable estimation and/or forecast accuracy (Nelson [1972]). A related finding (Pierce [1977]) is that predictions of many economic time series, once effective use of their own pasts has been made, can be little improved by using additional series. Even when there is a statistically significant relationship it is often "weak" in the sense that the prediction error variance is reduced only a few percentage points relative to the autoregressive extrapolation.

These and other problems render economic relationships connecting monetary aggregates to other variables difficult to determine with more than very small precision and confidence. Thus, in the conduct of monetary policy there is uncertainty about what the appropriate paths are for the "true" monetary aggregates, in addition to the uncertainty stemming from observable and unobservable errors in published versions of these series.

X. Discussion and Conclusions

That the published monetary aggregates are highly uncertain measures of the "true" U.S. money supply, for numerous reasons, is documented and discussed in this paper. We conclude by mentioning some potential implications of this for the construction and use of the monetary statistics.

The major sources of uncertainty were seen to be errors due to sampling and reporting, seasonal adjustment, and transitory effects. Reporting error can be kept to a minimum by continued efforts aimed at timely and accurate data collection and at monitoring the deposit data submitted to the Board and the Federal Reserve Banks. While sampling is no longer a source of error in estimating nonmember-bank components of monetary aggregates, survey sampling will continue to be needed for estimating deposits at institutions not required to report these data by the 1980 Monetary Control Act.

A recent research area in sample survey estimation is the use of historical information to improve the current survey estimate. A composite time series/sample survey estimate is in general a more accurate estimate than is the usual sample survey estimate, whether or not the survey errors are serially correlated. We are investigating the use of this approach in estimating the money stock series.

The possibilities for reducing seasonal adjustment error have been extensively researched in recent years. The Federal Reserve Board has engaged an outside Committee to examine problems in seasonally adjusting the monetary aggregates, which is expected to report its recommendations shortly. As noted earlier in the paper, greater flexibility (than X-11 enjoys) in tailoring the procedure to the statistical and economic characteristics of each series could reduce unobservable seasonal adjustment error. Observable error (revisions) could also be reduced in this way, and additionally by basing preliminary factors on all available information, including the current value and well-constructed forecasts of future values.

These and other ways to reduce error and uncertainty in the reported monetary aggregates are continually under study. But some error will always remain, reflecting both the present state of the art and of practice and the perhaps intrinsic limits on what can be achieved. Thus it is of greatest importance that error in these data be recognized and quantified. The potential for achieving this is a major advantage of constructing models for these series. Determination and dissemination of error estimates would warn users of the monetary aggregates against placing unwarranted emphasis on them.

REFERENCES

Bach, G. L., Phillip D. Cagan, Milton Friedman, Clifford G. Hildreth, Franco Modigliani, and Arthur Okun [1976], *Improving the Monetary Aggregates: Report of the Advisory Committee on Monetary Statistics*, Washington, DC: Board of Governors of the Federal Reserve System.

Barnett, William A., Paul A. Spindt, and Edward Offenbacher [1980], "New Concepts of Aggregated Money and their Expected Information Content," Special Studies Section, Federal Reserve Board.

Box, George E. P. and Gwilym M. Jenkins [1970], *Time Series Analysis, Forecasting and Control,* San Francisco: Holden-Day (Rev. Ed., 1976).

Cleveland, William P. [1972], *Analysis and Forecasting of Seasonal Time Series*, Ph.D. dissertation, Department of Statistics, University of Wisconsin.

Maravall, Agustin and David A. Pierce [1980], "Errors in Preliminary Money Stock Data and Monetary Aggregate Targeting," Special Studies Section, Federal Reserve Board.

Nelson, Charles R. [1972], "The Prediction Performance of the FRB-MIT-Penn Model of the U.S. Economy," *American Economic Review*, 62 (December), 902–17.

Pierce, David A. [1977], "Relationships—and the Lack Thereof—Between Economic Time Series, With Special Reference to Money and Interest Rates," *Journal of the American Statistical Association*, 72 (March) 11–22.

——— [1980], "Sources of Error in Economic Time Series," Special Studies Section, Federal Reserve Board.

Porter, Richard D., Agustin Maravall, Darrel W. Parke, and David A. Pierce [1978], "Transitory Variations in the Monetary Aggregates," *Improving the Monetary Aggregates: Staff Papers*, 1–34, Washington, DC: Board of Governors of the Federal Reserve System.

Shiskin, Julius, Allan H. Young, and John C. Musgrave [1967], *The X-11 Variant of the Census Method-II Seasonal Adjustment Program*, Technical Paper No. 15, U.S. Bureau of the Census, February.

Wallich, Henry C. and Peter M. Kier [1978], The Role of Operating Guides in U.S. Monetary Policy: A Historical Review, *Kredit and Kapital*, Berlin, January 11.

DISCUSSION

CHRISTOPHER A. SIMS*: Pierce *et. al.* have provided us with a valuable overview of the quantitative importance of month-to-month uncertainty in the current status of monetary aggregates and of the main sources of that uncertainty. Their conclusion that error due to problems with seasonal adjustment is of prime quantitative importance is both encouraging and discouraging—encouraging because it is understood how this situation could be improved; discouraging because it has been understood for a number of years now and yet the appropriate changes have still not been introduced.

The dramatic number of "misleading signals" from preliminary data displayed in figure 1 may in itself be somewhat misleading, however, precisely because some of these misleading signals arise from sources we know could be corrected for. In the case of seasonal data, the paper points out that re-estimation of seasonals contemporaneously, based on standard techniques, could greatly reduce the amount of *ex post* revision of preliminary figures. But sensible policy-makers, after observing the pattern of revisions over a few years (and sooner if they have time series analysts on their staffs) will recognize this source of discrepancy between preliminary and final figures and discount it. Thus a question arises which the paper does not directly address: what is the information gap between preliminary and final figures? It would be interesting to see a figure like 1 in which the preliminary figures were replaced by a least squares projection of final figures on preliminary figures for the preceding several months. This would give some idea of the extent to which there might be real lack of information about current developments in the aggregates.

The paper's discussion of the "policy seasonal" is interesting, and it raises issues which go beyond the question of measurement error. A policy of "control-

* University of Minnesota