M1: The ever-changing past

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Monetary policy hinges on the growth of M1 and its relationship to the rest of the economy. Newly released money supply data play a vital role in the policy process by providing information on current monetary conditions and the effect of recent policies. However, the initial money supply figures contain a high level of error[1] which may cause recent monetary growth to appear more erratic than it actually was. This makes it difficult for policymakers to determine if unexpected movements in initial M1 data reflect fundamental changes in economic behavior that require a new policy response.

Historical data are not as likely to exaggerate the volatility of money growth because over time the early data errors are reduced through frequent and often substantial revision. The various types of revision correct for reporting errors, incorporate data collected at infrequent intervals, comply with changes in money definition, and revise the factors that adjust the series for seasonal fluctuation. After several years, the data are more representative of actual economic history because they are based on more complete information. The volatility of the data is influenced most by the seasonal factor revisions since the other types of revision primarily affect the level, not the movement, of the series.

The relatively greater error in the most recent data may cause M1 growth to appear more variable in the current period than it was in the past. Policymakers may be led to believe that the monetary environment has suddenly become more volatile when in fact they are merely observing a statistical artifact.[2]

In this paper we examine the M1 data available to policymakers in every year since 1965 to see if initial perceptions of monetary behavior could have been seriously obscured by preliminary data errors.[3] We find that M1 growth often appeared to be significantly more variable in the most recent two-year period than it had been in the previous two years. However, in 50 to 60 percent of the cases this evidence of increased monetary uncertainty disappeared after two years of data revision.

These results suggest that perceptions of monetary relationships should not be dominated by the most recent unrevised data. Extreme preliminary values should not be considered strong indications of emerging trends unless there are compelling institutional or policy reasons to expect a change. Often, older data that have been through revision are a more reliable guide for monetary policy.

The overstated variance of initial M1 data has discouraging implications for the use of structural models to evaluate changes in economic relationships. The errors in the preliminary data will enhance the errors in recent estimations of such models, thereby increasing the probability of falsely detecting a structural change. This problem is more serious for models with more explanatory power. Since such models can account for more of the variance in the dependent variable, data errors will contribute a greater percentage of the total error. The errors will therefore exert proportionately more influence on tests for structural change.

Tests for distortion in newly released M1 data

This paper examines past experience with newly released M1 data to determine how seriously initial data errors could have distorted policymakers' view of their current monetary environment. In particular, we assess the influence such errors might have had on initial perceptions of the volatility or behavior of M1 growth.

Of all the revisions of M1 data, the recalculation of the seasonal adjustment factors is most likely to affect the variability of recorded money growth. There is a seasonal factor revision at least once a year which recomputes the factors for past years and calculates new factors for the upcoming year. The revised seasonal factors are calculated using

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nonseasonally adjusted money supply data through December of the previous year. The entire historical money supply series is readjusted with each seasonal factor revision. In recent years, these revisions have usually taken place in February or March.

The latter years in the money supply series are affected most by the seasonal factor revisions because recent seasonal factors are often changed substantially by the incorporation of another year of data. Normally, the seasonal factors for each year are calculated with data from the three previous years, the year itself, and the three future years. Preliminary seasonal adjustment factors must be estimated for the current year and years in the recent past because information on the future money supply is lacking for those years. As one more year of data is added with every revision, the seasonal factors for the three previous years are updated. (See box for detailed description of the seasonal adjustment process.)

We begin our study of initial data errors by recreating the monthly M1 data that was available to policymakers at the end of each year from 1965 through 1981.[4] For each of those 17 years we collected a series of M1 data which begins in 1959 and was adjusted by the most recent seasonal factor revision of the time. Each series incorporates every data revision made through December of its final year. For example, the series for 1980 extends from 1959 through 1980 and includes the latest revision of each number as of December 1980. The data in the 1980 series were seasonally adjusted under the seasonal factor revision of 1980.[5] Thus, we have 17 series of the most current data available to policymakers each year before they established money growth targets at the February FOMC meeting.

Next, we reconstruct the view policymakers had of the monetary volatility of their time by computing the variance of M1 growth in two-year intervals for each of the 17 series. We use an F test to determine if there were significant differences between the observed money growth variances in the three most recent two-year intervals in each series. Evidence of such differences could have suggested to policymakers that there had been a recent shift in monetary behavior.

The F tests for variance differences over the three two-year intervals are distorted by initial data errors because newly released data are compared to data that have undergone several years of revision. The time line in Figure 1 describes the three stages of data revision captured by the three data intervals in each series. Figure 2 illustrates the three stages with examples for the 1980 and 1979 data series. The most recent two-year interval in each series is in what we call the first stage of data revision. The seasonal factors applied at this stage are based on M1 data through the earlier of the two years in the interval. The next two-year period as we look back in time falls into the second stage of data revision. In this stage, one year is adjusted by seasonal factors which are missing two years of future data, and the other has factors missing one year of future data. The data interval furthest in the past is in the third stage of data revision in which the seasonal factors are based on a full three years of future data.

Because our collection of past data series ends with the 1981 series, the F tests are applied to two-year periods which go through all three stages of data revision. Thus, we can see how the F tests, our proxy for past policymakers' view of changes in money behavior, are affected by two years of data revision. First, we test each interval when it is in the first stage of revision to see if its variance is greater than that of the previous interval which is in the second stage. Then we perform the same test as it would have been two years later by comparing the variances of the same two periods once they move into the second and third stages of revision. This allows us to see how often initial evidence of shifts in monetary volatility is changed when more completely revised data become available.

Our collection of past data series can be used to further examine the effects of initial data errors on measured money behavior by following each period as it moves through the three revision stages. We calculate the changes in M1 growth variance for each interval as it travels from the first stage to the second stage and then from the second stage to the third.

Results of tests on newly released M1 data

The 17 overlapping two-year periods beginning in years 1964 through 1980 are tested to see if policymakers might have perceived them to be significantly more or less variable than previous years. At the five percent significance level, ten of the two-year intervals have significantly greater variance in the first stage of data revision than the preceding intervals have in the second stage. (See the first column in Table 1.) Thus, in 59 percent of the cases the newly released M1 data provided evidence that monetary volatility had increased. The F tests on the other seven intervals in the first stage of revision show that their variances are not significantly different at the five percent level than that of the preceding intervals. No

Figure 1
Three stages of data revision illustrated on time line

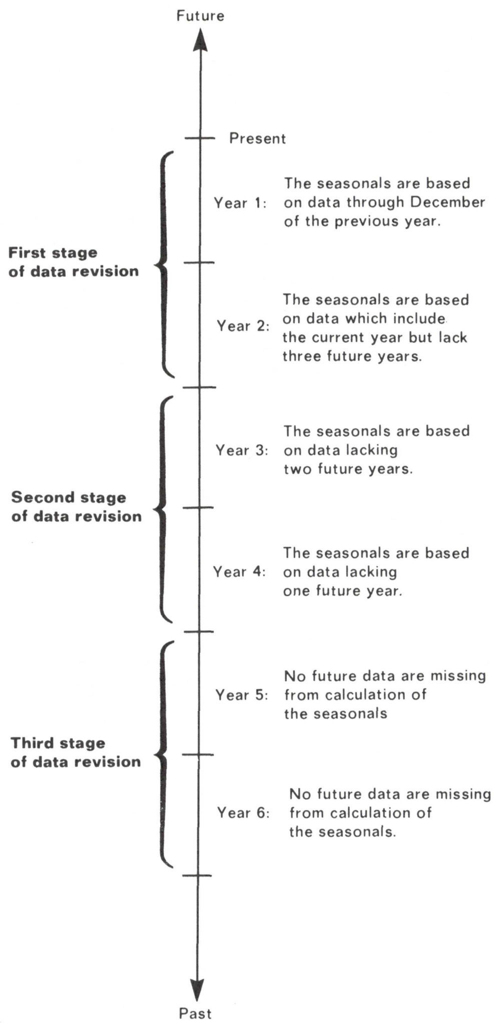
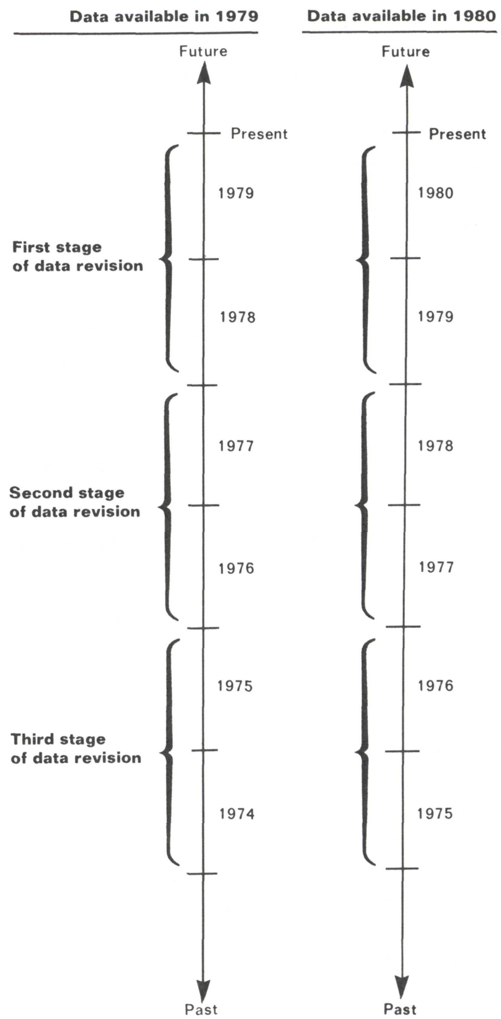


Figure 2
Examples of three stages of data revision for data available in 1979 and 1980



intervals in the first stage have significantly *less* variance than the earlier intervals in the second stage.

When intervals in the second stage of data revision are compared to earlier intervals in the third stage, the pattern of significantly reduced variance does not continue. The variance in the second stage is significantly greater than the variance in the third stage in only four out of the 17 periods. In three cases, the variance of intervals in the second stage is significantly less than the variance of intervals in the third stage, and in ten instances there is no significant difference between the variance of the intervals in the two stages.[6]

The F test results (at a five percent significance level) for the individual two-year periods are shown in Table 2. The four intervals which remain significantly more volatile than preceding periods after the two years of revision are clustered in the mid-60's and early 80's. Several events increased the uncertainty of the financial environment at both times, so there were good reasons to accept the initial evidence of increased monetary volatility. Both periods experienced severe credit crunches which induced large gyrations in money holdings. The introduction of ATS accounts in late 1978 and NOW accounts in late 1980 broadened people's options for managing transactions and savings balances. Shifts between new and old accounts contributed to erratic movements in measured money supply. In fact, in 1980 the Federal Reserve introduced two new money definitions (M1A and M1B) to prepare for various possible scenarios of the transition to the new accounts. The Federal Reserve's adoption of new operating procedures in 1979 was also a major financial change during the early 80's.

The findings in Table 1 suggest that the variance of M1 growth is vastly reduced by revisions during the two years after the data are first published, but that subsequent revisions do not have as large an impact. For the 17 two-year periods in our sample, the average variance fell by 34 percent as the data in each period moved from the first to the second stage of revision. (See Table 3.) The changes ranged from an 80.4 percent decrease to a 3.6 percent increase. After two more years of data revision, the average change in money growth variance

Table 1
Two-year variance of seasonally adjusted M1 growth compared to that of the preceding period at different stages of data revision 1964-1981

	Number of comparisons	
	5% significance level	10% significance level
Money growth variance in first stage and second stage of revision compared		
First stage greater than second stage	10	12
First stage less than second stage	0	1
Insignificant difference	7	4
Money growth variance in second stage and third stage of revision compared		
Second stage greater than third stage	4	6
Second stage less than third stage	3	3
Insignificant difference	10	8

Table 2
Results of tests for increased money growth volatility for each two-year period (F tests at 5% significance level)

Period initially more variable than preceding years		Period not initially more variable than preceding years	
More variable after data revision	Not more variable after data revision	Not more variable after data revision	More variable after data revision
	1964-65		
1965-66			
1966-67			
	1967-68		
		1968-69*	
		1969-70	
	1970-71		
		1971-72	
		1972-73	
		1973-74	
	1974-75		
	1975-76		
		1976-77*	
		1977-78*	
	1978-79		
1979-80			
1980-81			

*These periods were significantly *less* variable than the preceding period after two years of data revision.

Table 3
Change in two-year variance of seasonally adjusted M1 growth as each period moves through the three stages of data revision

Two-year period	Variance change from first stage to second stage	Variance from second stage to third stage
1964-65	-80.4%	-16.9%
1965-66	-65.4	14.2
1966-67	1.4	3.7
1967-68	-23.8	-13.9
1968-69	-26.2	.2
1969-70	3.6	-8.2
1970-71	-27.9	-3.5
1971-72	-41.2	-26.0
1972-73	-14.7	-21.2
1973-74	-41.9	7.7
1974-75	-59.0	29.2
1975-76	-18.3	3.9
1976-77	-76.0	36.0
1977-78	-58.7	-5.1
1978-79	-44.7	-4.4
1979-80	.7	9.1
1980-81	-4.1	6.0
1981-82*	-33.1	n.a.
1982-83*	-29.4	n.a.
Average change	-33.9	.6

*These years are not included in the average change or the F-test sample because they have not gone through all three stages of data revision.

Seasonal adjustment of the monetary aggregates

The procedure that the Federal Reserve uses to seasonally adjust the monthly money supply data is based solely on the behavior of the series itself. Using both past and future data, the process attempts to separate the seasonal movement in the data from movements due to the business cycle, long-term growth, and irregular shocks. These four components multiplied together are assumed to comprise the total money supply. To keep up with trends in the components, the seasonal factors for each year are based on weighted moving averages of the data over several surrounding years. Future and past data are weighted symmetrically in the calculation, with the greatest weight given to the years closest to the year being adjusted.

The precision of the adjustment is enhanced by computing separate seasonal factors for the different components of the monetary aggregates. The adjusted components are summed to obtain the total seasonally adjusted series.

Since 1982, the Fed has used the X-11-ARIMA seasonal adjustment procedure.[1] This method is a variant of the Bureau of the Census X-11 method. X-11-ARIMA and X-11 are identical when it comes to adjusting historical data, but they differ for data in the most recent years. The future data normally used for seasonal adjustment are not available for recent years, and the two methods cope with this problem differently.

For historical data, X-11-ARIMA and X-11 go through two iterations to separate the series into seasonal, trend-cycle, and irregular factors. In the first round, the trend-cycle component for each month is estimated with a moving average of the series over the 12 surrounding months. Each average is centered on the month in question. The trend-cycle components are divided into the unadjusted series to estimate the combined seasonal and irregular factors, which are called seasonal-irregular (S-I) ratios.

Monthly seasonal factors are then estimated with weighted averages of each month's S-I ratios over the previous two years, the current year, and the future two years. The weights are symmetric around the central year, and greater the closer they are to the central year. These averages of the S-I ratios smooth out the irregular shocks and thus provide initial approximations of each month's seasonal nature.

The estimated seasonals are then refined by reducing the influence of outliers in the data. Estimates of the irregular components, calculated by dividing the seasonal factors back into the S-I ratios, are used to identify such outliers. A moving standard deviation of the irregulars indicates which shock terms are extreme in value. The original series of S-I ratios is then corrected for outliers by removing or reducing ratios that have irregular terms larger than 1.5 times the moving standard deviation. Revised seasonal factors are calculated from this modified series of S-I ratios.

The process uses these revised seasonals to begin a second round of steps which refines the estimated trend-cycle and irregular terms and produces the final seasonal factors. First, the original data are adjusted by the revised seasonal factors so that a combination of the trend-cycle and irregular components remains. A second estimate of the trend-cycle is derived by applying a weighted average to this series. The length of this weighted average is determined by the relative variability of preliminary irregular and trend-cycle estimates. To smooth out the influence of the irregulars sufficiently, the span is made longer the greater the variability of the irregulars relative to that of the trend-cycle. Conversely, the span is shorter if the trend-cycle appears more variable. This allows trend-cycle shifts to be reflected better in the average.

The new trend-cycle component is then factored out of the unadjusted series to obtain revised S-I ratios. A centered seven-year moving average of the new S-I ratios yields new estimates of the seasonal factors. As before, the irregular terms are computed and the S-I ratios are modified for extreme values.

The final seasonal factors are then calculated by taking another seven-year weighted moving average of these modified S-I ratios. The factors are applied to the original data to get the final seasonally adjusted money supply series.

This procedure cannot be completely applied to recent data because it requires three years of future data. Therefore, the seasonal factors for the most recent three years are estimated at first and then revised in later years as the necessary data become available. X-11-ARIMA and X-11 have different methods for estimating the preliminary seasonals.

To calculate the seasonals for the most recent year, X-11 uses a different pattern of weights that applies only to past data. These weights are not symmetric, but they still put the greatest emphasis on the most current data. As future data become available, year by year, X-11 reestimates the seasonal factors with new sets of asymmetric weights that also cover the added data.

X-11-ARIMA computes the preliminary seasonal factors from past data and forecasts of the next year's data. It applies the weights X-11 uses when only one year of future data is available. The forecasts come from ARIMA (autoregressive integrated moving average) models. Such models provide minimum mean square error forecasts based on the past values of a series.

The seasonal adjustment process may be modified if an unusual sequence of events is known to have affected money supply behavior. Before the seasonals are computed, the effects of such events are identified and removed from the unadjusted money data with a statistical technique called intervention analysis. The seasonals calculated from the modified data are then applied to the unadjusted data to obtain the final seasonally adjusted series. The money supply data were corrected in this manner to remove the effect of the 1980 Credit Restraint Program.

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[1]X-11-ARIMA was adopted at the recommendation of the Committee of Experts on Seasonal Adjustment Techniques which advised that it might reduce the magnitude of money supply revisions. See Board of Governors of the Federal Reserve System (1981).

was only 0.6 percent. Again, the experience of individual periods was quite different, ranging from a 26 percent decrease to a 36 percent increase in growth variance.[7]

The large diversity in the variance reductions suggests that false detection of structural change cannot be easily avoided by stiffening the statistical test for such change, that is by lowering the acceptable p-values of F tests on the initial data.[8] The effect of data revisions on measured monetary volatility is so variable that a simple rule cannot correct the data error problem in all situations. In our sample, the 1964-65 period was initially found to be more variable than the preceding period with a very low p-value of 0.004. However, two years later the period was not significantly more variable at the five percent level than the previous period. Conversely, initial evidence that the 1980-81 period was significantly more variable with a very similar p-value of 0.002 was not overturned by a five percent test after two years of data revision.[9]

The large and rapid decline in money growth variance is simply a statistical phenomenon that occurs as incorporation of more data allows the seasonal factors to capture more of the seasonal movement in the data. Changing patterns in seasonality will be reflected more accurately in the seasonal factors as data for the current year and one or two future years are included in the calculation. These improved factors will reduce the variance of the adjusted series in two ways. First, they can remove the seasonal variance from the series more completely. Second, because the revised seasonals are better estimates of actual seasonality they do not introduce as much variance into the data through error as the preliminary seasonals do.

Money growth variance can also be reduced if the addition of data for the current year causes some of the variance in the unadjusted series, whether seasonal or not, to be attributed *directly* to seasonal fluctuation. While attempts are made to minimize absorption of current nonseasonal variance into the seasonals, some of the reduction in money growth variance that we observe may be due to this effect.

After a few years the revisions do not affect the variance of seasonally adjusted money as much because they do not produce large changes in the seasonal factors. The future data incorporated in the later revisions carry little weight in the computation of the seasonal factors, so their addition does not alter the seasonals or the seasonally adjusted data substantially. This accounts for the small changes in money growth variance between the second and third stages of data revision.

While the pattern of variance changes that we observe has a simple statistical explanation, the problem it poses for policymakers is quite serious. Out of the ten sample cases in which the current environment appeared more volatile than the previous two-year period, only four were still significantly more variable after two years of revision. Thus, there was a 60% chance that an apparent increase in money growth variability would disappear from the data within two years. At the 10 percent significance level, initial indications of increased volatility were eliminated by data revision in 50 percent of the cases. Six out of the total 17 periods, or 35 percent, under either significance level yielded false signals that the monetary environment had grown more erratic. The exaggerated picture of money growth volatility provided by recent money supply numbers could lead policymakers to take unnecessary corrective measures.

Implications for structural models

Errors in the preliminary money supply data can create problems for models which include M1 either as a dependent or an independent variable. Models of money growth are subject to data error bias when they are used to test for recent changes in the relationship between money and certain economic factors. Such tests compare the variance of the model errors before and after a change is presumed to have taken place. A statistically significant increase or decrease in error variance is considered evidence of a shift in monetary behavior. Preliminary data errors could distort these tests by adding to the noise observed for the model in the most recent period. This may so raise the variance of recent errors relative to that of earlier errors that tests for structural shifts in the model will find false significant evidence of change.

In fact, the F tests of M1 growth variance provide an example of the bias initial data errors introduce into tests of economic models. The F test is equivalent to a test for change in a simple model of M1 growth which includes only an intercept term and a dummy variable equal to one during the more recent two-year period. The model's predicted values for the two periods in question are equal to the means of M1 growth in those periods. Therefore, the variances of the model errors used in a test for structural change between the two periods are identical to the variances of M1 growth used in our F tests.

Unfortunately, tests for change in money growth models that include additional explanatory factors will experience greater bias due to preliminary data errors than our F tests. This is because the more sophisticated models explain more of the variance in M1 and so have lower errors. Initial data errors will contribute a larger share of the errors in such models so long as the data errors are uncorrelated with the model's independent variables. As a result, the recent model errors are more likely to appear significantly larger than earlier errors simply because of noise in the unrevised data. Therefore, our finding that 50 to 60 percent of detected variance changes prove to be statistical artifacts may represent the lower bound of this bias problem.

Preliminary data errors can cause four types of bias in models where M1 appears as an explanatory variable. First, the errors in the M1 data will increase the variance of measured model errors, so that tests for structural change may be biased for these models as well. Second, M1 data errors will cause the estimated coefficients of the M1 variables to be biased toward zero. Third, models which include lagged values of M1 may have longer lags and lower coefficients on the recent lags than they should.[10] As a result, such models will give the impression that the dependent variable's relation to M1 has slower response time and more memory than it actually does.

Finally, the added noise in current M1 data will increase the variance of predictions from such models. This effect is greater if the M1 variable has a large coefficient. The influence of preliminary data errors on prediction variance is more complicated for models with lagged values of M1 because the total effect will be determined by the pattern of the M1 coefficients over time. For example, if a model has twelve lagged M1 variables with approximately equal coefficients, the effects of errors in the seasonals will be largely cancelled out. Aside from this restrictive case, it is difficult to estimate the full influence of initial M1 data errors on predictions.

However, even though initial data errors may bias models of M1's relationships with other economic variables, it is not necessarily preferable to use nonseasonally adjusted M1 data instead. The variance of unadjusted M1 data is dominated by the variance of the seasonal component; from 1959 through 1984, the variance of the estimated seasonal component was 28 times greater than the variance of the nonseasonal component. Thus, any model which uses unadjusted M1 data must model the seasonal patterns very accurately before it could possibly capture the economic behavior of money. Since the seasonal and nonseasonal components must be estimated simultaneously, it is difficult to obtain a model which is not contaminated throughout by the seasonality of the data.

Conclusion

Our examination of the money supply data that was available to policymakers in the years from 1965 through 1981 shows that newly released numbers often provided misleading information about the monetary environment. The preliminary money supply data frequently indicated that money growth was more variable in the current period than it had been before. However, the evidence of increased volatility was often merely an artifact of the incomplete nature of the initial seasonal adjustment factors. In 50 to 60 percent of the cases where money growth seemed to have grown significantly more variable, the evidence of greater variance was eliminated after two years of data revision. While our work is not extensive enough to offer a correction for this problem, it does suggest that preliminary seasonally adjusted M1 values which seem extreme should be interpreted and used in economic modelling with great caution.

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[1] We use the word "error" to refer to the difference between the initial M1 estimates and the final revised figures. However, because the revision process is imperfect, this difference may not always accurately reflect the true errors in the preliminary data.

[2] The effect of errors in preliminary money supply data has been recognized as a problem by the Board of Governors research staff for some time. Pierce (1980) derives the statistical properties of seasonal factor revision under several seasonal adjustment methods. He then calculates the standard deviation of the seasonal factor revisions for M1 and the commercial paper rate in the mid-1970's. Pierce (1981) uses the standard deviation of all noise in the monetary aggregates to determine how long an observed deviation from trend growth must persist to be statistically significant evidence of a shift in trend. This work is concerned with the magnitude and behavior of initial data errors and the influence such errors have on measures of money and money growth levels. Such information is useful to determine if money growth is off target.

[3] Federal Reserve policy did not target M1 at all times over this period. However, we include as many years as possible in our sample in order to refine our tests for the influence of preliminary data errors on measured volatility of M1.

[4] For 1980 and 1981 we recreate the M1B data that was available to policymakers because that money definition was adopted as the new M1 measure at the end of 1981.

[5] For years in which there was more than one historical revision we concentrate on the most recent one because it provides a complete series through the end of the calendar year.

There was no seasonal factor revision in 1972. The money supply numbers during that year were seasonally adjusted under the November 1971 seasonal factor revision. Thus, for 1972 we examine the behavior of the November 1971 money supply series as it existed at the end of 1972.

[6] The F test results are virtually the same when the influence of the Credit Restraint Program of 1980 is reduced by leaving the months of March and April 1980 out of the sample.

[7] It is possible that the switch from the X-11 method to X-11-ARIMA in 1982 may have reduced the errors in the initial seasonals. (See box for explanation of this change.) X-11-ARIMA will lower errors caused by unusual current observations because it assigns less importance to the most recent data. However, X-11-ARIMA cannot reduce the noise in the early numbers if such errors are caused by the failure of the seasonal adjustment process to pick up rapid trend changes in seasonality. In this case, X-11-ARIMA would actually exacerbate the problem by reinforcing the influence of past seasonal patterns on the preliminary seasonal factors.

Our sample does not cover any data after the conversion to X-11-ARIMA because those years have not yet moved through all three stages of data revision. However, preliminary evidence on the effectiveness of X-11-ARIMA is offered by the experience of the 1981-82 and 1982-83 intervals which have gone through the first two stages of data revision. The money growth variance in these two periods declined 33 and 29 percent respectively between the most recent and the middle stages of revision. These declines are so near the average change for the intervals in the sample that they suggest that X-11-ARIMA has not substantially reduced the excessive variance in recent seasonally adjusted money data.

Hein and Ott (1983) also find that initial monthly data are still biased with X-11-ARIMA. However, they cite evidence from Stone and Olsen (1978) that weekly numbers are closer to later revised data when adjusted by X-11-ARIMA.

[8] The p-value is the probability that the variance is not greater in the more recent period for each value of the F statistic. In other words, it is the probability of accepting a false hypothesis at each point on the F distribution. It is standard practice to accept a hypothesis if the probability of being wrong is five percent or less, i.e. if the p-value is less than or equal to 0.05.

[9] This p-value was for the test when March and April 1980 were excluded from the sample in order to nullify the influence of the Credit Restraint Program. When these months were included in the sample, the p-value was 0.0002.

[10] Telser (1981), pp. 233-256.

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