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The Problem of Seasonally Adjusting Money

by John B. Carlson

When an impending surge in the money supply filled the financial news in March of this year, the reports stated that the surge would result from above-average income-tax refunds and early Social Security payments. Consistent with expectations, M-1 (which includes currency plus checkable deposits) grew 11.8 percent (saar) in April 1982. But personal tax refunds occur every year. And early Social Security payments occur whenever the third day of a month falls on a Saturday, Sunday, or holiday. The fact that these and other effects relate to seasonal or recurring events and can be predicted suggests a serious question. Why doesn't seasonal adjustment of the money supply filter all such movements?

This *Economic Commentary* examines the problem of seasonal adjustment, using April 1982 as an example; this particular month reflected a number of influences that can distort seasonally adjusted monthly measures of money. Although there is scope for improving the accuracy of estimated seasonal factors, fundamental improvements of the current method of seasonal adjustment will require extensive research. Such a research program recently was implemented at the Board of Governors of the Federal Reserve System.[1]

1. For a more thorough discussion of seasonal adjustment and the board's research program, see David A. Pierce and William P. Cleveland, "Seasonal Adjustment Methods for the Monetary Aggregates," *Federal Reserve Bulletin*, vol. 63, no. 12 (December 1981), pp. 875–87.

Why Seasonally Adjust M-1?

The primary reason for seasonal adjustment is to eliminate repetitive movements from data that obscure movements of greater significance to the user. For policymakers and market analysts, the main current interest in the money supply is its target property, i.e., information about whether the Federal Reserve is supplying bank reserves too liberally or too sparingly. In practice, the policy of the Federal Reserve has been to accommodate changes in money demand that "meet the needs of the trade" (i.e., seasonal movements) to the extent that such demands are consistent with achieving longer-term objectives, particularly the annual growth-rate targets for M-1 and the broader measures of money stock. Thus, the Federal Reserve sets its monetary growth-rate targets in terms of seasonally adjusted data, accommodating seasonal fluctuations that are temporary and offsetting. Errors in measurement of seasonality thereby can lead to difficulties in conducting monetary policy.

Seasonal Movements in the April Money Measures

In its most limited sense, ***seasonality*** refers to movements in data that occur precisely at the same time each year with the same intensity. As it is typically used, *seasonality* refers to all repetitive movements that occur on predetermined dates, but which need not occur on the same date nor with the same intensity. In this broad sense, economic series that display seasonality exhibit fairly consistent patterns of fluctuation, recurring at predictable but not necessarily uniform intervals.

Historically, the April pattern has been one of large recurring increases in the raw data, particularly in the checkable deposit component. Over the past five years, this component has increased an average annual rate of 53.4 percent in April (see table 1). This pattern has been attributed largely to the effects of income-tax flows (both refunds and receipts) that are concentrated in April, although other factors probably were also at work. Presumably, many refunds are deposited in transactions accounts soon after they are received, tending to inflate money balances. How quickly deposit holders adjust their balances to "normal levels" is not clear. Although it sometimes is assumed that they adjust fairly quickly (i.e., within two months or so), evidence supporting this is indirect and ambiguous.

Money-supply increases associated with federal income-tax receipts, on the other hand, arise from float due to mailing and tax processing, as payors' deposit balances remain high until checks clear. Typically, by early May the Treasury has collected over 90 percent of all individual nonwithheld tax payments due April 15. In April 1982, the Treasury processed over $35 billion in such receipts. Decreases in raw-money numbers in May tended to offset much of the increase in April.

The M-1 surge in April 1982 also may have reflected specific details of the calendar. Such variations, known as ***calendar effects***, may result from payment practices affected by non-regularly recurring holidays (e.g., Easter), the day of the week on which the month begins, or the number of Fridays in the month. These effects generally do not occur at uniform intervals, nor do they always occur in the month of April.

One calendar effect, which seems to be growing in importance, is the consequence of early Social Security payments. These payments usually are made on the third day of the month, unless the third falls on a weekend; then payments are made on the first business day prior (Friday, unless it is a holiday). The third day of April 1982 fell

Table 1 Transactions Deposit Growth in April

Seasonally adjusted annual rates

Year	Raw number, percent	Seasonal component,[a] percent
1978	57.0	40.4
1979	64.7	42.8
1980	17.4	42.9
1981	71.4	40.6
1982	56.4	43.7
Average	53.4	42.1

a. Seasonality is estimated, using the ratio of the first published seasonals for April and March.

on Saturday, so that these payments (amounting to over $13 billion) were made one day early. Early payments are likely to be deposited earlier (over one-third are deposited directly), while expenditures by Social Security recipients are not likely to be altered by early payments. Unless the recipients immediately transfer deposited funds into nonmoney assets or use balances to purchase goods or services from those who do, transactions balances would be higher than they otherwise would have been. Thus, early payments make the weekly average money-supply measure higher than it otherwise would have been. If one assumes that neither receipts nor expenditures in the second week are affected by the early payments, the impact should wash out completely in that week. To the extent that balances are temporarily high for one day, average monthly balances would be higher, but only about one-fourth the average weekly effect.

Calendar effects in weekly data are fundamentally different from calendar effects in monthly data. A monthly calendar effect that could have contributed to the recent M-1 surge relates to the number of Fridays in April. When a month has five Fridays, a large percentage of people who are paid biweekly receive three paychecks instead of their usual two. Money balances tend to swell in such a month and the month immediately following. (Such an effect occurs twice a year in biweekly payment cycles.) To the extent that households pay monthly obligations out of the more typical two-payday income flows, these households would have more discretionary funds available in the extra-payday months. Since it is unlikely that all of the extra funds are immediately transferred into nonmoney assets or used to purchase goods and services, transactions balances temporarily rise. Although balances in a five-Friday month are on average marginally higher, in the first month following they could be as much as $1 billion higher. This effect is essentially zero by the second month.

The influence of an extra pay period on the money numbers probably has intensified in recent years, as large firms (with large payrolls) have adopted more sophisticated cash-management techniques. One such technique—zero balancing—allows firms to invest all available cash on a daily basis. As funds are transferred from firms (holding money-market assets) to households (holding funds in checkable deposits), the narrow money measures tend to increase.

Seasonally Adjusting the Money Measures

When approaching the problem of seasonality, we should have some knowledge of the underlying behavior generating the data to choose the appropriate technique for adjustment. The behavior of deposit holders suggests reasons for relating changes in seasonality of money-supply components to readily measured variables, such as the volumes of tax receipts and refunds. In principal, all basic determinants of seasonality could be included as part of a more general model explaining the behavior of each of the raw-money components. Assuming their relationships could be well estimated, seasonal effects could be forecast and eliminated to obtain the seasonally adjusted series. (Seasonal forecasts for the upcoming year would require that all contemporaneous determinants also be forecast.) Unfortunately, such a model has not been established, nor is it evident that a widely accepted model could be estimated.

In the absence of an established structural model, the money supply—like virtually all economic time series—is adjusted using an auto-adjustment method, i.e., seasonal variation is based solely on the past history of the variable being adjusted. The specific method, which follows from the X-11 program developed by the Bureau of the Census, is applied to each of the components of the money supply (see box). Each monthly seasonal factor is essentially a weighted average of the values of the data for that month over a number of years once the trend-cycle component has been factored out. The number of years averaged and the values of the weights are options of the user and should depend on prior knowledge. If the seasonal is known to be changing, for example, the period over which those data are averaged should be short, and the weights given to the most recent data should be relatively larger. The most recent information is given the most weight.

The auto-adjustment approach assumes that all information about the relevant magnitudes of seasonality in money is embodied in the past history of the series itself. The fact that the financial markets anticipated the M-1 surge in April based on expectations of tax flows challenges this assumption. Although the X-11 method clearly fails to anticipate all systematic changes in seasonality that result from changes in underlying determinants, the X-11 contains an option that allows it to detect and partly account for trend change over time.[2]

There is some evidence indicating that the X-11 can better anticipate changing seasonality when augmented with time-

2. This option adds one-half the change from the previous year to the seasonals of the last available year. While such a formula may be rigid, it will, on average, detect and partially account for trend change, particularly if this change is large relative to the irregular movements. Furthermore, X-11 results are sometimes modified judgmentally to incorporate expected fluctuations resulting from institutional changes, such as a change in the tax-filing date. Because it is difficult to perform this practice consistently over time, it is done only under extreme circumstances. Consistent anticipation of all systematic changes in seasonality requires more complete knowledge of the underlying determinants.

The X-11 Method

The X-11 is the method employed to estimate monthly seasonal factors.[1] The X-11 involves two fundamental steps to separate any monthly time series into three distinct series—the ***trend-cycle***, ***seasonal***, and ***irregular components***. The first step isolates the trend-cycle component from the seasonal and irregular components by dividing the original series by an estimate of the trend-cycle component. The second step separates the seasonal and irregular components. The X-11 procedure is iterative in two senses: (1) it repeats the second step, using a revised seasonal component in which extreme irregular values are eliminated or replaced with dampened ones; (2) it repeats both steps by re-estimating the trend-cycle component, using alternative averaging methods on a preliminary seasonally adjusted series obtained in subsequent rounds.

Although the technique is considered mechanical, it permits the use of judgment to the extent that some parameters of the X-11 program can be varied. This discretion is best exemplified by the user's options for choosing both the length of the period and the weighting structure of the moving average. The moving average options are available when estimating both the trend-cycle and seasonal components of the series. Although the X-11 automatically selects default values for these options, the user has available alternatives that permit variations in the degrees of smoothing.[2] When estimating the final trend cycle, the degree of smoothing (length of moving average) desired would depend on the relative importance (average percent change) of the irregular variations to the trend-cycle movements. The greater the irregular movements relative to the trend cycle, the longer the moving average needed to smooth out the short-term movements and reveal the trend. Conversely, if cyclical movements dominate, then a short moving average would better reveal the systematic movements of the series.

Similarly, when estimating the seasonal components, the degree of smoothing desired would depend on the relative importance of the regular variation. If a seasonal for a given month is believed to be stationary, then all the movement in the seasonal-irregular (S-I) component for the month must result from irregular variation. Thus, the user would choose to average as many years of that month as possible to average out the noise. For this reason, the X-11 has an option that averages seasonal-irregular values of the same month for all prior years available, giving equal weight to each year.

If the seasonal factor is believed to be changing, then movements in the S-I component reflect movements of both individual components, and the default option may be desirable. This option takes a five-year moving average that weights most heavily the S-I component in the year being estimated. The two years before and the two years after are weighted with lesser weights (declining away from the year). When the seasonal being estimated is for the most recently available year, only the two prior years are included. Although a short moving average may fail to average out irregular noise, it enhances the probability that a seasonal factor would correctly incorporate movements reflecting fundamental changes in the determinants of seasonality. It also enhances the probability of removing irregular variations under the guise of seasonal variations. The tradeoff is clear. If *a priori* evidence exists that movements in the seasonal are large relative to irregular variation, then a short averaging period is desired.

1. Estimating weekly seasonals is a complex process in which the weekly results are prorated to be consistent with the X-11 results on monthly data.

2. Experience has shown that the seasonal component of many economic time series can be adequately estimated by the same choices of X-11 options. Consequently, the X-11 program is preset to these default options, which can be changed as circumstances warrant.

series methods (e.g., X-11 ARIMA). Unlike structural models, time-series models are based solely on statistical principles and thus are particularly useful in forecasting when theoretical knowledge is scarce. Information contained in time-series projections of the money-supply components can improve seasonal forecasts in the sense that subsequent revisions of the factor are reduced. When the X-11 is applied to an extended time series of a given component, which consists of the available observations and the projected values of the unadjusted series, the resulting seasonal forecasts are closer to their final values, which are determined only after the future data are known.[3]

Another problem with the X-11 is that it does not adequately filter calendar effects, as they do not occur in the same month each year. Although the X-11 has an option to estimate the effects of the number of trading days in a month using a regression model, it has not been useful in eliminating such calendar effects in money. Recent studies have indicated that spectral analysis methods may prove useful for detecting calendar effects; the magnitudes of calendar effects then can be estimated using regression methods.[4]

Alternative models also may provide a framework for constructing an adequate filter. A simple statistical test suggests variations in the irregular component—the series after X-11 estimates of both trend-cycle and seasonal components have been factored out—are explained by the day of the week on which the month begins.[5] A further implication is that estimated coefficients of this model provide measures of the magnitudes of calendar effects. Unlike more ambitious efforts to model the determinants of seasonality, research on modifying the X-11 to detect and measure calendar effects is likely to produce more immediate improvements in seasonal adjustment of the money supply.

Improving Seasonal Adjustment Methods

In early 1978 the Federal Reserve Board initiated a comprehensive study to determine appropriate methods for seasonally adjusting financial data, particularly the money-supply measures. Published in 1981, the study's recommendations essentially outlined a continuing research program—one that subsequently was implemented.[6] Because possibilities exist for improvements in the widely used and accepted X-11 program, the Federal Reserve Board's continuing research effort initially will focus on developing model-based improvements, including time-series modeling options and calendar adjustments. The Federal Reserve also will experiment with more general model-based methods that can incorporate causal explanations of seasonal patterns and measure systematic effects. The Federal Reserve's research program thus can be expected to yield more immediate results from X-11 enhance-

3. Judging the quality of a preliminary seasonal-factor estimate by how close it is to its final value (once all data are available) has been challenged as being only as accurate as the final estimate allows. In the absence of a universally accepted set of criteria, however, it is perhaps the most popular standard.

4. See William S. Cleveland and Susan J. Devlin, "Calendar Effects in Monthly Time Series: Detection by Spectrum Analysis and Graphical Methods," *Journal of the American Statistical Association*, vol. 75, no. 371 (September 1980), pp. 487–96. See also William P. Cleveland and Michael R. Grupe, "Modeling Time Series When Calendar Effects Are Present," Special Studies Paper 162 (Board of Governors of the Federal Reserve System, 1981; processed).

5. Specifically, the X-11 estimate of the irregular component of demand deposits was regressed on variables accounting for the day of the week on which the month begins. The estimation period was January 1976 through December 1979. The F-statistic of the regression was 5.19, which indicates that one cannot reject the hypothesis that movements in the irregular component are explained by the monthly starting day. Indirectly, this evidence supports the hypothesis that the calendar effects are consequences of early Social Security payments and extra pay periods, since it is necessary (although not sufficient) that a month begins on a Thursday or Friday or (in some months) Wednesday for these events to occur.

6. See Board of Governors of the Federal Reserve System, *Seasonal Adjustment of the Monetary Aggregates*, Report of the Committee of Experts on Seasonal Adjustment Techniques (Board of Governors, October 1981).

ment research while laying the foundation for fundamental changes—ideally, a breakthrough leading away from the basic auto-adjustment framework.

The study also recommended that the Federal Reserve Board consider using the present seasonal-adjustment procedure or its recommended modification on a *concurrent* basis to utilize all available data for estimating seasonal factors. Using the most current data would produce smoother initial estimates and reduce the size of revisions compared with the practice of projecting seasonal factors for the year ahead. However, concurrent estimation would entail a number of costly revisions each month as new data are used by the procedure. A reasonable compromise might be to estimate the seasonals semiannually, thus allowing incorporation of the most current information for mid-year review of the money targets. Semiannual calculations also would provide better estimates of the April seasonal soon after the raw data for April become available.

Conclusion

Ideally, seasonal adjustment should filter all calendar-related movements, so that movements remaining in the seasonally adjusted data cannot be attributed to difficulties in estimating seasonal factors. The fact that the April surge in *seasonally adjusted* M-1 was attributed to seasonal causes reveals shortcomings in the method used. As recommended in the Fed's study of seasonal adjustment, an ongoing research program has been organized to develop better methods of adjustment. While modifications of the current methods are likely to lead to improved estimates of the seasonal factors, fundamental improvements, such as the development of causal adjustment methods, may not be available for implementation for some time to come.

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