# ISOLATING INSTABILITY IN MONEY SUPPLY FORECASTS

Joe Brocato, Economics, North Texas State University
Kenneth L. Smith, Economics, North Texas State University

## Abstract

*Previous studies present conflicting evidence on the rationality and efficiency of weekly money supply forecasts. Many studies have found that these forecasts meet the criteria of the Rational Expectations Hypothesis of unbiasedness, efficiency, and consistency. However, other research has found biasedness in the 1979-1982 period. We utilize a battery of tests to assess these criteria for money market survey data from September 1977 through October 1984. By breaking the available data set into six month subperiods we identify the 1980-1981 period as one of market turbulence producing biased and inefficient money supply forecasts. This evidence is supported by employing the Brown-Durbin-Evans cusum of squares statistic. A plot of this statistic indicates structural instability in the relationships tested in 1980. Factors which may have contributed to this turbulence in 1980 were the Federal Reserve's shift from an interest rate target to an M1 target in late 1979, the Monetary Control Act of 1980, the imposition of credit controls in 1980, and the volatility in the velocity of M1 in 1980-1981. Importantly, even though the U.S. monetary environment remained turbulent over the 1979-1982 period, our results show the weekly forecasts of money market dealers reachieving statistical rationality after 1980.*

## Introduction

Much attention has been paid recently in the literature to weekly forecasts of money market participants obtained from Money Market Services of San Francisco. Many of these studies, but not all, have found that these forecasts meet the criteria of the Rational Expectations Hypothesis, i.e., unbiasedness, efficiency, and consistency. Rationality is much more likely to prevail when markets are functioning smoothly in a stable environment. We find, however, that testing rationality over fairly long periods of time can potentially conceal episodes when forecasts, on average, are not on the mark. These are periods when market participants are not processing information efficiently. During these intervals of market turbulence we are likely to observe systematic errors in forecasts.

Previous studies present conflicting evidence on the rationality of these same money supply forecasts. Roley [6] and Pearce and Roley [5] find unbiasedness and efficiency over the period September 1977 through October 1982. We extend this earlier analysis by utilizing the usual tests to assess rationality and efficiency of money market survey data through December 1984. Like Pearce and Roley [5], for the entire period (September 29, 1977 through December 31, 1984) we find evidence of unbiasedness and efficient forecasts. Hafer [2] finds unbiasedness and weak-form efficiency during the intervals January 11, 1978 through October 3, 1979 and January 11, 1978 through June 16, 1982. He is able to isolate the subperiod October 10, 1979 through June 16, 1982 as a period of biased, but weak-form efficient forecasts. Like Hafer, we break the full sample into subperiods. Unlike Hafer's fairly long subperiods, we break the sample into six month subperiods. By doing so we are able to isolate early 1980 as a period of biased and inefficient forecasts. We find that prior to this subperiod and immediately following, money market forecasts reachieve the statistical properties of rationality. These results confirm those of Pearce and Roley, Roley, and Hafer, but with the battery of tests which we utilize to assess rationality applied to our six month intervals we bring into sharp relief the period of greatest market turbulence. Finally, we offer several events which characterized the turbulence in financial markets in the early 1980 period as likely causes for the irrationality. During this period the Fed changed from an interest rate target to an M1 target (October 1979), the Monetary Control Act was passed by Congress (March 1980), and credit controls were imposed and then released by the Federal Reserve (March 1980 through May 1980).

## The Data

The survey data come from Money Market Services', Inc. weekly survey of approximately 60 money market participants. The full sample period runs from September 29, 1977 through December 31, 1984. Prior to February 8, 1980 the Fed announced weekly changes in M1 on Thursdays (M1B prior to January 31, 1982). During the period Money Market Services, Inc. surveyed participants on both Tuesday and Thursday of each week. The median of the Thursday survey is used as the measure of expected money. Following February 8, 1980 the Fed announced weekly changes in money on Fridays. During this period the surveys were taken only on Tuesdays. Actual money levels were taken from the Federal Reserve's weekly H.6 release.

## Tests for Forecast Biasedness and Instability

The standard equation used to test for unbiasedness of forecasts is to regress actual money on expected money

$$(1)\ M(A)t = b0 + b1M(E)t + et$$

where et is a mean-zero white noise process. The test hinges on the ability to reject the joint null hypothesis that b0 = 0 and b1 = 1. Table 1 presents our results for the six month intervals.1 These intervals are based on an expanded sample period through December 1984. Full period results, September 1977 through December 1984, are reported at the bottom of the table. The last column reports results of the joint hypothesis of b0 = 0 and b1 = 1. For the full period we are unable to reject the joint hypothesis. However in the subperiod, January 1980 through June 1980, we reject the hypothesis at the .05 level. In the subperiod July 1980 through December 1980 we reject the hypothesis at the .10 level. While our subperiod analysis allows us to identify approximate periods of instability, a clear drawback of this procedure is the requirement of at least some prior knowledge as to the exact date of a structural change occurring within periods. In order to bring into sharper relief possible breaks in the data, we employ the Brown-Durbin-Evans [1] cusum of squares statistic. It is calculated from the recursively estimated residuals from equation (1).2 While the cusum of squares statistic does not provide a formal test, it is a useful technique in that it provides information about possible structural breaks (see Harvey [3], p. 152). Figure 1 shows a plot of the statistic for the period March 9, 1978 through June 25, 1982.3 Examination of Figure 1 is suggestive of instability in the early 1980 period. Thereafter, the function coalesces into a stable relationship with the plot closely paralleling its expected value as given by the diagonal.

An additional test useful in analyzing forecast error is the Thiel decomposition of the mean square of forecast error (MSFE). The MSFE is derived from equation (1) and provides a statistical measure of "average" forecast accuracy.4 The procedure decomposes the forecast error (M(A)t - M(E)t) into the bias, variance, and random components, with the decomposition providing some information on how well the forecasts meet the rationality requirements b0 = 0 and b1 = 1 as given in equation (1). If the forecasts are unbiased then the values of the bias and variance components should compose a very small percentage of the total MSFE, and the random component should be close to unity. Errors in prediction leading to a positive value for the bias component indicate errors in central tendency and amount to a consistent under- or over-estimation bias in the forecasting model. The variance component characterizes errors associated with the slope component, b1 in equation (1). To the extent that expectations are characterized by errors concentrated in the slope component, these errors are associated with forecasts which systematically under- (over-) estimate large changes in M(A)t, and over- (under-) estimate small changes in M(A)t, depending upon whether the intercept in equation (1) is positive or negative. Also, it can be shown that as the component SC approaches zero, b1 approaches unity. Finally, the random component represents the dispersion of residuals obtained from regressing the announced on forecasted magnitudes in equation (1). Since the variance of announced money is always positive, the random component will equal zero only if M(A)t and M(E)t are perfectly correlated. Given the random nature of the disturbance term, et, this is unlikely. The random component can be viewed as a measure of the unsystematic component affecting the accuracy of the forecasts, with the accuracy being inversely related to the variance of the probability distribution of the residuals.

In Table 2 we report results of this test for our six month intervals. The MSFE is greatest in the January 1980 through June 1980 period. In terms of the random component (RC) of the MSFE its percentage is lowest (73%) during this interval. The statistic also indicates that the variance component (SC) is greatest (27%) during this period. Finally, we see the absolute size of the MSFE is greatest for the early 1980 period. Analysis of the results indicates that the slope component is responsible for increased absolute value of the MSFE for this period. These results indicate that changes in the expected money series less accurately follow changes in actual money than in previous and subsequent subperiods.

## Test for Efficiency

Weak-form efficiency results if the actual money stock and the forecasted money series follow the same time series structure. Thus, we find that

(2) M(A)t = b0 + b1M(A)t-1.

With efficiency we have

(3) M(E)t = b0' + b1'M(A)t-1.

By combining equations (2) and (3) we get equation (4). The test for efficiency hinges on the statistical significance of b0 and b1 in5

(4) (M(A)t - M(E)t) = b0 + b1M(A)t-1.

We test the null hypothesis that b0 = b1 = 0, b0 = (b0 - b0'), and b1 = (b1 - b1'). We report our results for efficiency in table 3. Like Pearce and Roley [5] we are unable to reject efficiency for our full period, September 1977 through December 1984. However, by breaking the full sample into our six month intervals we are able to identify two subperiods, January 1980 through June 1980 and January 1981 through June 1981, where we are able to reject efficiency. These results are suggestive of market turbulence as indicated by the biasedness tests reported in table 1, by the Thiel mean square forecast error decompositions as shown in table 2, and by the plot of our cusum of squares statistic from equation (1) shown in Figure 1.

## Forecast Revisions

The structure of expectations can be modeled and tested. The adaptive expectations model is written as6

(5) $(M(E)t - M(E)t-1) = b0 + b1(M(A)t-1 - M(E)t-1)$.

The left hand side represents the forecast revision in response to the previous week's forecast error, the right hand side variable. In each subperiod we found the coefficient to be positive, ranging from .36 to .88. This indicates that past money announcement surprises are met with an upward revision in money forecasts.7 Our results for estimating equation (5) provide no clear-cut evolution in the coefficients and we, therefore, do not present our results.

Again, however, the Brown-Durbin-Evans test provides greater detail in identifying breaks in the data. Figure 2 is a plot of the Brown-Durbin-Evans cusum of squares statistic from equation (5). Although these breaks are within the 10% confidence bounds, the plot shows a period of instability occurring in early 1980. These results are consistent with those shown in Figure 1 and our battery of tests which indicate instability in the early 1980 period.

## Policy and Institutional Shifts in 1980

The evidence from the battery of tests which we have presented is consistent with the story of monetary turbulence in the early 1980 period. In the following paragraph we outline likely causes for biasedness and inefficiency of money supply forecasts exhibited over this period (see Mishkin [4] for an excellent summary of these events, pp. 392-395).

In late October 1979 the Fed deemphasized the fed funds rate as its intermediate target, replacing it with a nonborrowed reserves target. The objective was to better control the money supply. However, the growth rate of the money supply became more, not less variable. It is well-recognized that this policy change contributed to monetary instability. Furthermore, then-President Jimmy Carter, in order to fight inflation, ordered the Federal Reserve System to impose credit controls during the March through May 1980 period. The effect of this policy was to constrain consumer and business loans. Growth of money fell sharply with the implementation of credit controls and the accompanying recession, and then rose sharply when controls were lifted in May 1980. In addition, the growth rate of M1 velocity became quite variable in the 1980-1981 period. This confounded the Fed's efforts to hit the M1 target, thus, causing the money supply to be endogenous. The resulting variability of money from week-to-week contributed to the lack of money supply forecasting precision during this period. Another factor contributing to monetary turbulence was the combination of a nonborrowed reserves target and lagged reserve accounting. If loan demand for a given week was particularly strong, banks could make the loans and thereby create more money. Two weeks later banks would scramble for reserves to meet their increased reserve requirement. Thus, in order for all banks to be able to meet their reserve obligations, the Fed was compelled to supply reserves. Rather than the money supply being exogenous, it was, to a large extent, endogenous. On the one hand, market participants heard the Fed's pronouncements about controlling the money supply, but, on the other hand, the Fed's performance fell short of its objective. In such a turbulent environment forecasting money on a weekly basis very likely would not meet the two statistical requirements of the Rational Expectations Hypothesis tested in this paper, unbiasedness and efficiency.

## Summary and Conclusion

We have contrasted our six month period results for rationality of money supply forecasts with earlier research. We conclude that estimation of biasedness and efficiency over fairly long periods masks periods of unbiasedness and inefficiency. We have shown that the forecast data in the first six months of 1980 exhibited biasedness and inefficiency. This is in sharp contrast to earlier results of Pearce and Roley [5] who found unbiasedness for the period 1977 through 1982 and Hafer [2] who identified the entire period 1979--1982 as a period of biased forecasts. We show that prior to and after 1980 forecasts were unbiased. We also find that efficiency of forecasts holds except for the 1980-81 period. In contrast to Hafer we find unbiasedness and efficient forecasts for 1982. We note that prior to 1980 and immediately following, forecasts reachieve the properties of rationality, unbiasedness and efficiency.

## FOOTNOTES

1. Typically time is removed from money supply data via first differencing when the data are expressed in levels. While this is an acceptable procedure when a large number of observations are available, problems in estimating the true parameters are encountered when a small number of observations are used. In particular, differencing removes much of the correlation in the data and, while the estimates remain unbiased, the small number of data points increases the estimated coefficient variances drastically, making it difficult to interpret the results. Estimation in levels makes the estimates less sensitive to the small sample size and allows us to isolate any correlation between actual and expected money. Of course, this procedure does introduce the possibility that the results will be spurious due to the presence of a common time trend. In order to check for this possibility, the partial F-values on time and expected money from equation (1) were estimated. The partial F-value on time (alone) for the full period is F = 9.98; for expected money, with time already in the model, it is F(1,339) = 10,173. These results indicate the measured subperiod relationships are not due solely to the presence of a common time trend. The levels were generated by adding to the forecast the previous week's observed money supply M(A)t-1.

2. The cusum of squares statistic (WWt) is calculated as

$$WW_t = \sum_{t=k+1}^{t} v_t^2 \Big/ \sum_{t=k+1}^{T} v_t^2$$

where $v_t$ are the one-period-ahead standardized forecast errors for period t+1 from the regression truncated at period t. The procedure analyzes the behavior of a series of normalized recursive residuals (squared), $v_t^2$, which are one-period-ahead prediction errors obtained from regressions performed over successively longer sample ranges. Defining $v_t^2$ to be the standardized difference between the actual values of the dependent variable at time t and the forecast value from a regression fitted over all previous observations, it can be shown that $v_t^2$, t=1 . . . T, has a zero expectation under the null hypothesis of no structural change. However, if a structural change has occurred then the underlying model parameters are constant only through some period t* and $v_t^2$ will have a nonzero expectation in the post change period. See Harvey ([3] p. 152) for a complete description of the computation of the statistic. As is well known the BDE procedure is inappropriate when the error structure exhibits heteroscedasticity. Statistical examination of the errors indicates they are characterized by a common variance.

3. Unlike Table 1, Figure 1 is only plotted over the early 1978 through late 1982 period. The published confidence bounds accompanying the cusum of squares statistic constrained us to a maximum of 203 observations. Constructing the statistic using all observations did not present an appreciably different pattern from that shown in Figure 1. The confidence bands are drawn at the 10 percent level.

4. The Thiel decomposition of the mean square forecast error is derived from equation (1) as follows:

$$\text{MSFE} = (\bar{M}(E) - \bar{M}(A))^2 + (\sigma_{M(E)} - r\sigma_{M(A)})^2 + (1-r^2)\sigma_{M(A)}^2$$

where $(\bar{M}(E) - \bar{M}(A))$, the bias component is represented in table 2 as MC, $(\sigma_{M(E)} - r\sigma_{M(A)})^2$, the variance component, is represented in table 2 as SC, and $(1 - r^2)\sigma_{M(A)}^2$ the error component, is represented in table 2 as RC. The table is presented so that the proportion of the mean square forecast error is attributed to one of the three components so that in parentheses we have the bias proportion (MC/MSFE), variance proportion (SC/MSFE), and residual variance proportion (RC/MSFE). Of course, these proportions must sum to unity.

5. For each subperiod we added an additional lagged actual money term (M(A)t-2) to the information vector. In each period it was statistically insignificant, thus we excluded it from equation (4).

6. Fitting an ARIMA model to the full period, we find that a first-order moving average process adequately represents the data. As is well known, a first-order moving average process can be rewritten as the adaptive form seen in equation (5).

7. We tried fitting a second order adaptive model to all subperiods and found evidence that it fit the data in only one subperiod, July 1980 through December 1980. This is indicative that market turbulence produced a more complex error structure in this subperiod.

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## TABLE 1

## BIASEDNESS TEST

$$M_t^A = \beta_o + \beta_1 M_t^E + \varepsilon_t$$

| | $\beta_o$ | $\beta_1$ | D.W. | $\bar{R}^2$ | $F{:}H_o$<br>$(\beta_o=0, \beta_1=1)$ |
|---|---|---|---|---|---|
| September 1977-June 1978 | -28.15<br>(-1.2) | 1.08$^{***}$<br>(15.8) | 1.76 | .92 | .40 |
| July 1978-December 1978 | 27.01<br>(.96) | .92$^{***}$<br>(11.7) | 2.11 | .86 | 1.80 |
| January 1979-June 1979 | -11.32<br>(-.27) | 1.03$^{***}$<br>(8.9) | 2.24 | .78 | .74 |
| July 1979-December 1979 | 39.3<br>(1.53) | .90$^{***}$<br>(13.2) | 2.03 | .89 | 1.21 |
| January 1980-June 1980 | 127.5$^{***}$<br>(2.8) | .67$^{***}$<br>(5.7) | 2.13 | .61 | 3.91$^{**}$ |
| July 1980-December 1980 | 34.77<br>(1.3) | .92$^{***}$<br>(13.6) | 1.84 | .91 | 2.57$^{*}$ |
| January 1981-June 1981 | 52.5<br>(1.65) | .88$^{***}$<br>(11.6) | 2.13 | .85 | 1.64 |
| July 1981-December 1981 | -21.47<br>(-.25) | 1.05$^{***}$<br>(5.3) | 2.51 | .58 | .08 |
| January 1982-June 1982 | 114.12<br>(1.52) | .75$^{***}$<br>(4.5) | 2.09 | .49 | 1.96 |
| July 1982-December 1982 | -14.24<br>(-.75) | 1.03$^{***}$<br>(25.2) | 1.79 | .97 | .46 |
| January 1983-June 1983 | 18.19<br>(.80) | .96$^{***}$<br>(21.0) | 2.23 | .95 | 1.49 |
| July 1983-December 1983 | 77.44<br>(1.3) | .85$^{***}$<br>(7.4) | 2.69 | .70 | .99 |
| January 1984-June 1984 | 13.87<br>(.48) | .97$^{***}$<br>(18.0) | 2.52 | .93 | .22 |
| July 1984-December 1984 | 23.84<br>(.22) | .96$^{***}$<br>(4.8) | 2.28 | .52 | 1.01 |
| Full Period | -.179<br>(-.25) | 1.00$^{***}$<br>(604.3) | 2.09 | .99 | .30 |

$^{*}$Significant at the .1 level.

$^{**}$Significant at the .05 level.

$^{***}$Significant at the .01 level.

TABLE 2

## THIEL MEAN SQUARE FORECAST ERROR DECOMPOSITION

MSFE = MC + SC + RC

| | MSFE | MC | SC | RC |
|---|---|---|---|---|
| September 1977-June 1978 | 2.216 | .011 | .039 | 2.166 |
| (%) | (1.0) | (.005) | (.018) | (.977) |
| July 1978-December 1978 | 3.190 | .316 | .120 | 2.754 |
| | (1.0) | (.099) | (.038) | (.863) |
| January 1979-June 1979 | 3.557 | .197 | .010 | 3.350 |
| | (1.0) | (.055) | (.003) | (.942) |
| July 1979-December 1979 | 1.559 | .003 | .157 | 1.399 |
| | (1.0) | (.002) | (.101) | (.897) |
| January 1980-June 1980 | 8.077 | .001 | 2.190 | 5.886 |
| | (1.0) | (.00) | (.271) | (.729) |
| July 1980-December 1980 | 6.480 | .916 | .419 | 5.145 |
| | (1.0) | (.141) | (.065) | (.794) |
| January 1981-June 1981 | 6.846 | .154 | .697 | 5.995 |
| | (1.0) | (.022) | (.102) | (.876) |
| July 1981-December 1981 | 4.881 | .022 | .015 | 4.844 |
| | (1.0) | (.005) | (.003) | (.992) |
| January 1982-June 1982 | 7.100 | .444 | .659 | 5.997 |
| | (1.0) | (.063) | (.093) | (.845) |
| July 1982-December 1982 | 3.069 | .044 | .084 | 2.941 |
| | (1.0) | (.014) | (.027) | (.958) |
| January 1983-June 1983 | 5.392 | .501 | .129 | 4.762 |
| | (1.0) | (.093) | (.024) | (.883) |
| July 1983-December 1983 | 3.073 | .034 | .209 | 2.830 |
| | (1.0) | (.011) | (.068) | (.921) |
| January 1984-June 1984 | 4.077 | .037 | .015 | 4.025 |
| | (1.0) | (.009) | (.004) | (.987) |
| July 1984-December 1984 | 4.458 | .365 | .010 | 4.083 |
| | (1.0) | (.082) | (.002) | (.916) |
| Full Period | 4.344 | .006 | .002 | 4.336 |
| | (1.0) | (.001) | (.000) | (.998) |

Percentage of MSFE shown in parentheses.

TABLE 3

## TEST FOR EFFICIENCY

$$(M_t^A - M_t^E) = \beta_o + \beta_1 M_{t-1}^A + \epsilon_t$$

| | $\beta_o$ | $\beta_1$ | D.W. | $\bar{R}^2$ |
|---|---|---|---|---|
| September 1977-June 1978 | 28.47 | -.08 | 1.85 | .05 |
| | (1.3) | (-1.32) | | |
| July 1978-December 1978 | 64.71 | -.18 | 2.14 | .11 |
| | (1.6) | (-1.67) | | |
| January 1979-June 1979 | 106.03 | -.29 | 1.83 | .09 |
| | (1.5) | (-1.52) | | |
| July 1979-December 1979 | 10.86 | -.028 | 2.16 | .02 |
| | (.57) | (-.57) | | |
| January 1980-June 1980 | 87.39 | -.19* | 1.65 | .14 |
| | (1.8) | (-1.81) | | |
| July 1980-December 1980 | 12.89 | -.03 | 2.06 | .01 |
| | (.33) | (-.32) | | |
| January 1981-June 1981 | 63.16 | -.15* | 2.28 | .14 |
| | (1.93) | (-1.92) | | |
| July 1981-December 1981 | 81.86 | -.19 | 2.18 | .04 |
| | (.92) | (-.92) | | |
| January 1982-June 1982 | 123.33 | -.27 | 2.12 | .10 |
| | (1.5) | (-1.5) | | |
| July 1982-December 1982 | -12.91 | +.03 | 1.87 | .01 |
| | (-.45) | (.48) | | |
| January 1983-June 1983 | -1.22 | +.01 | 2.35 | .0003 |
| | (-.04) | (.08) | | |
| July 1983-December 1983 | 93.32 | -.18 | 2.12 | .04 |
| | (1.02) | (-1.02) | | |
| January 1984-June 1984 | 10.40 | -.02 | 2.56 | .01 |
| | (.51) | (-.51) | | |
| July 1984-December 1984 | 120.81 | -.22 | 1.25 | .05 |
| | (1.04) | (-1.04) | | |
| Full Period | -1.33 | .003 | 2.03 | .01 |
| | (-1.43) | (1.52) | | |

*Significant at .1 level

Figure 1. Cusum of squares plot for equation 1: $M_t^A = \beta_0 + \beta_1 M_t^E + \epsilon_t$

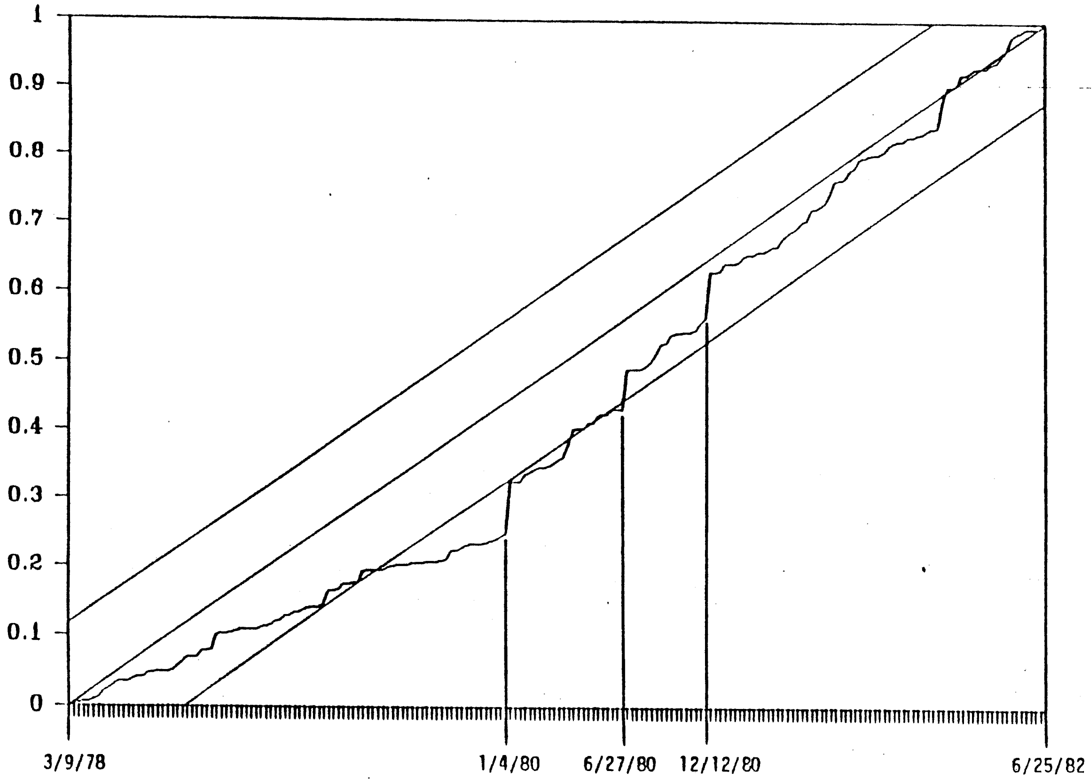

Figure 2. Cusum of squares plot for equation 5: $(M_t^E - M_{t-1}^E) = \beta_0 + \beta_1 (M_{t-1}^A - M_{t-1}^E) + \epsilon_t$