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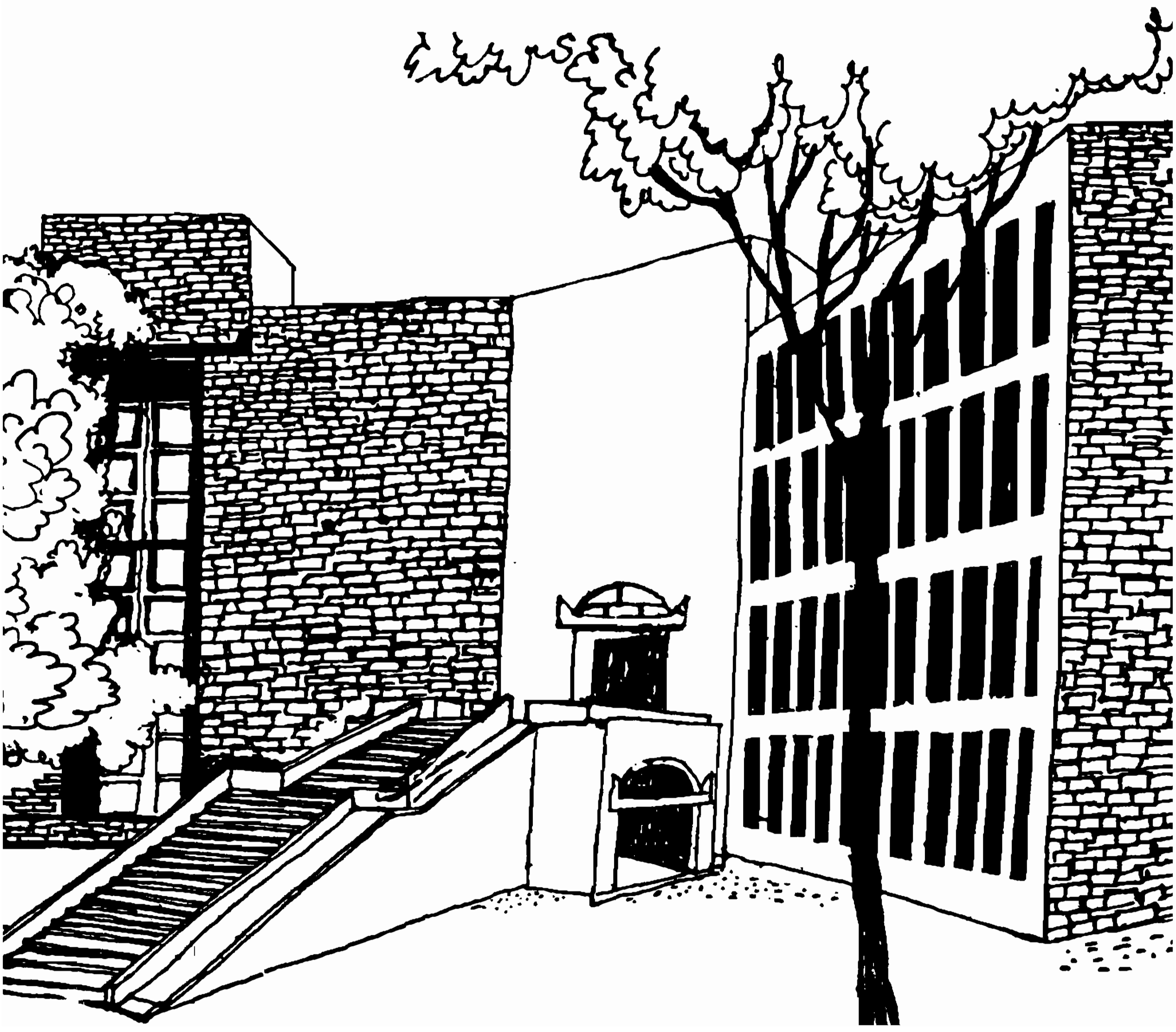

FORECASTING MONEY SUPPLY USING BOX-JENKINS AND OTHER PROCEDURES

By

G. S. Gupta

W P No. 1128
August 1993

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INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380 015
INDIA

Forecasting Money supply Using Box-Jenkins and Other Procedures

G.S. Gupta [*]

1. Introduction

The quantity of money in circulation (money supply) is an important economic variable, for it is a significant determinant of GNP and inflation rate, inter alia, which are components of high level goals. The significance of money supply is particularly more in the present day context because its growth rate is now monitored by the International Monetary Fund, World Bank and other international lending organizations. While the Government of India and the Reserve Bank of india are trying hard to control the growth rate in money supply, their efforts have not yielded high results. Furthermore, it is not easy to tamper the growth rate in an aggregate variable, and thus forecasting through appropriate statistical and econometric methods could still yield good results. Also, the forecasts would be desirable to assess the impact of new economic policies on money supply, which would be available through a comparison of the actual money supply and the money supply forecasts obtained through statistical methods. In view of this, the paper attempts to generate money supply forecasts using the most sophisticated statistical method, viz. Box-Jenkins method, other appropriate statistical methods, and the regression method.

The research is based on the quarterly (last Friday) data for the period 1970-01 through 1992-04 on the broad concept of money (M_3) and other pertinent variables, and provides forecasts on M_3 for the period 1993-01 through 1995-04. In the regression method, data from 1970-01 to 1992-02 were used, for those on the interest rate for the last two quarters were not available. The accuracy of the within sample period forecasts has also been examined in order to judge the a priori credibility of our forecasts. The broad money concept (M_3) is used, for the definition of the narrow money (M_1) has undergone a definitional change during the sample period and there is no authentic series on M_1 for the entire period. For the ease of notation, we will devote M_3 as M in what follows. In all computer runs and in the text, including equations, all money variables are measured in crores of rupees and interest rate in percentages.

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[*]The author is BOB Chair Professor in International Banking and Finance at Indian Institute of Management, Ahmedabad. He is grateful to Ms. G. Vijaya and Mr. H. Keshava for their assistance in data collection and computer runs, and the Research and Publications Committee of IIMA for granting the necessary fund.

2. Money Supply Series

An examination of the pertinent time series must precede its forecasting efforts. During the sample period of this study, money supply declined, that too only marginally, only in two quarters, viz. 1972-03 and 1974-04, and in all other periods it witnessed an increasing trend. Thus, the variable under forecasting has increased practically monotonically over time. A further examination of the series reveals some seasonal variations as well and that was expected due to fluctuating growth rates during the busy and slack seasons. In view of this nature of the series, the following methods are considered appropriate for forecasting the money supply:

a. Box-Jenkins method
b. Decomposition method
c. Exponential Smoothing methods
d. Regression method

3. Box-Jenkins Method

The Box-Jenkins method, also known as the Auto-regressive integrated moving average (ARIMA) method, involves four steps: identification, estimation and verification of the model, and derivation of forecasts[1]. Identification of the appropriate ARIMA model is attained through an examination of the auto correlation (AC) and partial auto correlation (PAC) coefficients of various orders, and testing the significance of a group of ACs on the basis of the Box-Pierce Q statistic[2]. Through this procedure, it was found that both M_3 as well as its first difference series were non-stationary, but the two period seasonal difference of the first difference series was stationary. Thus, the transformed variable Z_t, as defined below, turned out to be stationary, on the basis of which the ARIMA model could be estimated:

$$X_t = M_t - M_{t-1} \qquad \ldots\ldots (1)$$

$$Z_t = X_t - X_{t-2} \qquad \ldots\ldots (2)$$

[1]For details on Box-Jenkins method, see Makridakis, et al (1983), Chapter 9.

[2]Vide Makridakis, et al (1983), pp. 390-1.

For the Z_t series, auto correlation coefficients of only orders 2 and 11, and partial auto correlation coefficients of only orders 2, 6, 11, 12 and 18 were found to be somewhat significant. Several alternative ARIMA models for Z_t were estimated using the TSP package, the results of the best fitted model are given below:

$$Z_t = \underset{(3.20)}{245.19} - \underset{(2.91)}{0.5378}\, Z_{t-2} - \underset{(2.44)}{0.4227}\, Z_{t-6} + \underset{(1.70)}{0.3520}\, Z_{t-11}$$

$$- \underset{(2.90)}{0.5280}\, Z_{t-12} - \underset{(2.77)}{0.6623}\, Z_{t-18} + \underset{(1.68)}{0.3763}\, e_{t-2} + \underset{(2.15)}{0.4832}\, e_{t-11}$$

$$R^2 = 0.4679,\ DW = 1.85 \qquad \ldots\ldots (3)$$

$[e = \text{error} = \text{actual } Z - \text{estimated } Z\ (\hat{Z})]$

In the above equation, all variables are denominated in crores of rupees, numbers in parentheses are corresponding t-values, R^2 = coefficient of determination and DW = Durbin-Watson statistic's value. All the t-values are significant at 10% level or less, DW value rules out the serial correlation problem and the R^2 value is fairly good, particularly for a doubled difference variable. Thus, the estimation results of the ARIMA model are good. To verify the appropriateness of the model, auto and partial auto correlation coefficients of the residual term for various lags were obtained and the Box-Pierce Q test was applied to the group of the first 25 lags' auto correlation coefficients. None of these individual coefficients as well as the group of coefficients were found to be significant.

Yet another test for the goodness of the model would be to examine the accuracy of the within sample period (expost) forecasts[3]. This was attempted on the basis of three quantitative statistics, whose values are found to be as follows:

$$MPE = 0.296, \quad MAPE = 1.74, \text{ Theil } U_2 = 0.490$$

Mean percentage error (MPE) provides the measure of bias, Mean absolute percentage error (MAPE), the measure of the average absolute error in percentage, and Theil U_2 is a relative measure, which compares the forecasting accuracy of the method in relation to that of the naive method (forecast of variable Y in period t+1 = Y_t). All these errors are

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[3]For details on accuracy measures, see Makridakis, et al (1983), pp.43-54.

rather small and this establishes the credibility of our ARIMA model for forecasting the money supply. Since the money supply has changed basically uni-directionally, there is little scope for applying the qualitative accuracy measures, such as turning point and directional error measures.

The forecasts on money supply ($\hat{M}_t$) were obtained through using the following equation, which follows from equations 1 and 2 above:

$$\hat{M}_t = \hat{Z}_t + M_{t-1} + M_{t-2} - M_{t-3} \qquad \ldots\ldots (4)$$

The values for $\hat{Z}_t$ were obtained through equation (3), and the actual values of M_{t-1}, M_{t-2} and M_{t-3} were used for the periods until which they were available and for the other periods the boot-strapping method was resorted to, under which the estimated values of the lagged variables instead of their true values were used. The so obtained forecasts for the money supply for the next three years are provided in the Table, Column 2. A discussion on these forecasts is presented later when all alternative forecasts are evaluated and compared.

4. **Decomposition Method**

Under the decomposition method, the four components of a time series are first separated and the results are then used to generate the forecasts[4].

Firstly, the alternative trend functions were fitted to the quarterly money supply data, and the function which yielded the highest explanatory power (R^2) was selected to generate the trend component. The best trend equation turned out to be the following:

$$\log_e M = 9.0537 + 0.0406\,T$$

$$R^2 = 0.993 \qquad \ldots\ldots (5)$$

$$(T = 1, 2, \ldots\ldots\ldots, 92)$$

[4]For details on the Decomposition method, see Pindyck and Rubinfeld (1991), Chapter 14.

Application of equation 5 for different values of T yielded the trend component. Secondly, the seasonal component indices were derived through the following steps:

a) Four Period moving averages (MA) and then the central moving averages (CMA) were obtained from the original money supply (M) series.

b) Division of M by CMA yielded the seasonal-cum-irregular (SI) component.

c) Irregulation component (I) was separated from SI series through arranging the data by quarters and computation of quarterly averages. Adjustment was also made to ensure that the sum of the four seasonal indices was unity. The values of the seasonal indices so obtained turned out to be 0.9956, 1.0136, 0.9879, and 1.0029 for quarters 1, 2, 3 and 4, respectively.

Thirdly, the irregular component's series was obtained by dividing SI series by the corresponding seasonal indices. Finally, the cyclical component (C) was derived on the residual basis by dividing the original money supply series by the product of the trend, seasonal and irregular components. In the process, as always, we lost four data points, viz. 1970-01, 1970-02, 1992-03 and 1992-04. The multiplication of the four components, by design, is identical to the corresponding actual value of money supply, and hence there is no error in within the sample period forecasts in the decomposition method. Accordingly, all accuracy measures (e.g. MPE, MAPE, Theil U_2) take a zero value.

To generate the post-sample period forecasts, we use the trend equation (5), seasonal indices as obtained above, and some estimates for cyclical (c) and irregular (I) components. There is no perfect method to forecast C and I components. These are either ignored or are obtained through the use of some leading indicators. In this paper, these two components are obtained as their corresponding average values for the corresponding quarters during the last three years. The so obtained values of these two components for the four quarters are as follows:

Quarter	C	I
1	0.9973	1.0027
2	0.9952	0.9934
3	0.9955	1.0092
4	0.9971	0.9971

The use of equation (5), and seasonal, cyclical and irregular indices yielded the desired post-sample period (ex anti) forecasts for the money supply, which are reported in the Table, Column 3.

5. Exponential Smoothing Methods

There is more than one exponential method which is appropriate for forecasting a non-stationary series like money supply. These include Brown's double exponential smoothing method, and Holt-Winter's non-seasonal, additive seasonal and multiplicative seasonal exponential smoothing methods[5]. The TSP package contains all these methods and accordingly this package was used to derive both the within sample as well as the post-sample period forecasts. The most appropriate values for the various parameters under the various methods were found as follows:

Method	Parameters		
	Smoothing	Trend	Seasonal
Brown	0.43	-	-
Holt-Winter: No Seasonal	0.48	0.48	-
Holt-Winter: Additive Seasonal	0.73	0.36	0.40
Holt-Winter: Multiplicative Seasonal	0.71	0.35	0.87

Both within the sample period as well as the post-sample period forecasts were obtained under all these four exponential smoothing methods. The values for the various accuracy measures for within the sample period forecasts turned out to be as follows:

[5]For details on exponential smoothing methods, see Makridakis, et al (1983), Chapter 3.

Method	Accuracy Measures		
	MPE	MAPE	Theil U_2
Brown's	-0.334	2.78	1.00
Holt-Winter: No Seasonal	0.247	2.17	0.629
Holt-Winter: Additive Seasonal	-1.43	3.69	1.955
Holt-Winter: Multiplicative Seasonal	-1.60	4.80	2.573

As per these accuracy measures, the Holt-Winter: no seasonal model turns out to be the best method for reproducing the history. The post-sample period forecasts obtained through this method are included in the Table, Columns 4-7.

6. Regression Method

Under the regression method, a causal model is first formulated, it is then estimated using the historical data, verified on the basis of theoretical and statistical tests, and then used to derive both the expost and ex anti forecasts[6]. The causal model could be specified either through the demand or the supply route. The demand route would formulate the money demand function, which would have national income as the most important explanatory variable. Since the quarterly data on income are not available, the demand route could not be adopted. Under the supply route, the money supply function could be hypothesized as follows:

$$M = f(H, i) \qquad \ldots\ldots (6)$$

Where H = high-powered (government) money
i = interest rate (%)

Both the short-term interest (Bombay call money) rate as well as the long-term interest rate (government bond yield), and different functional forms were tried. The results with long-term rate and linear form turned out to be better than all others. Also, there was the problem of auto-correlation, which was corrected through the use of the

[6]For Details on the regression method, see Pindyck and Rubinfeld (1991), Chapter 8.

Cochrane - Orcutt iterative procedure[7]. Further, the data on government bond yield were not available for the last two quarters, and hence the sample period for the regression method consisted of 1970-01 to 1992-02. The estimated results of the best fitted money supply function are as follows:

$$M = -23606.0 + 2.8038\,H + 3821.59\,i \quad \ldots\ldots (7)$$
$$\quad (4.58) \qquad (33.46) \qquad (4.09)$$

$R^2 = 0.9989$, $\rho = 0.3232$, DW = 1.74
(ρ = first-order auto correlation coefficient).

The results in equation (7) are very encouraging. All the coefficients assume a priori expected signs, both H and i are significant determinants of M, and the values of R^2 and DW are the most appropriate ones.

The TSP package was used in the estimation of equation (7) as well. Under this package, expost forecasts were obtained through two steps. One, the estimated generalized difference equation, viz.

$$(M-\rho M_{-1}) = 23606\ (1-\rho) + 2.8038\ (H - \rho H_{-1}) + 3821.59\ (i - \rho i_{-1}) \quad \ldots\ldots (8)$$

was used to generate estimated values for $(M - \rho M_{-1})$. Two, the estimated values for M were obtained as

$$\hat{M} = \widehat{(M - \rho M_{-1})} + \rho M_{-1} \quad \ldots\ldots\ldots (9)$$

The so obtained expost forecasts turned out to be reasonably good as indicated by the following measures of their accuracy:

MPE = -0.327, MAPE = 3.31, Theil U_2 = 0.968

For obtaining the ex anti forecasts through the regression method, we need forecasts on the explanatory variables (H and i) for the post-sample period. These were obtained by the trend method, where first the exponential growth rates in H and i were obtained and then these were applied to the last available actual values of the corresponding variables to yield the desired data. The growth rates in H and i turned out to be 3.68% and 1.08% per quarter, respectively. The forecasts on H and i, equations (8) and (9), and the

[7] Vide Pindyck and Rubinfeld (1991), pp.141-2.

boot strapping method were used to derive the ex anti forecasts on M (under boot strapping, the estimated values for M_{-1} were used when its true values were not known). the so obtained forecasts on the money supply are reported in the Table, Column 8.

7. Evaluation of Forecasts

All forecasts are subject to errors and the alternative forecasts on the money supply in India contained in the Table are no exception. Further, since the data on actual money supply in any of the forecast periods are not yet published, there is no way to assess their accuracy and to support the one set of forecasts over the others. However, certain comparison and observations can still be made, which follows:

a) As expected, all forecasts reveal a monotonically increasing size of money supply in the country.

b) The Box-Jenkins method yields the most conservative forecasts while the decomposition method the most liberal forecasts. Incidentally, recall that the most significant component of the decomposition method forecasts are the trend magnitudes, which are expected to slow down under the new economic reforms, beginning July 1991. In view of this, the decomposition forecasts being on the higher side is no surprise and they are less reliable than others.

c) Theoretically speaking, the regression forecasts could be taken as superior to all other forecasts, for the former are based on sound economic theory (and as such are explanatory besides being prescriptive) while the latter are simply extrapolatory (only prescriptive and not explanatory).

d) On the basis of the accuracy measures of the expost forecasts, the Box-Jenkins forecasts are the best (decomposition method is ignored here, for it is associated with perfect expost forecasts, by construction).

e) Among the exponential smoothing forecasts, the Holt-Winter's no-seasonals' are the best on the accuracy criteria. The money supply forecasts under this method are always higher than those under the Box-Jenkins method but their relationship with those under the regression method is changing over time. To be precise, the regression method forecasts lower money supply during the first four quarters of the forecast period (1993-01 to 1993-04) and higher during the remaining quarters than does the no-seasonal Holt-Winter method.

It is impossible to recommend one set of forecasts over the others on the basis of the theory and past records. For, if this were possible, only one method of forecasting could have been used instead of several. Nevertheless, arguments could be offered to support one set over the other in a particular case. We know that the government is striving hard to check the growth rate in money supply but the efforts are not likely to yield significant results in the short-run. In view of this and in view of the findings given above under points (a) to (e), the non-seasonal Holt-Winter forecasts appear to be the most convincing. Thus, our recommendations are the following:

a) If one were to provide a single forecast, than those contained in Column 5 of the Table may be taken as our forecasts for the money supply in India during the next 12 quarters.

b) If alternative forecasts could be given, then our most conservative forecasts are the ones contained in Column 2 of the Table, and the most liberal ones are those given in Column 2 of the Table. The most likely forecasts could be taken as those in Column 5 of the Table.

8. Conclusion

The alternative methods used for forecasting the money supply in India during the next 12 quarters have revealed good fits but varying results. Since no method is perfect and no method used here is useless, all alternative forecasts are useful. As per the results, the money supply in India could be as small as Rs.4,764 billions or as large as Rs.5,814 billions by the end of 1995-04. Hopefully, it will lie somewhere between these two estimates. Our best estimate would be around Rs.5,000 billions as yielded by the non-seasonal Holt-Winter method. Needless to say, these estimates are derived on the basis of an analysis of historical data and so if far reaching economic reforms continue or become more vigorous, we may witness the money supply figures different from our all forecasts, and the difference would provide an estimate of the impact of economic reforms on the money supply. Nevertheless, the magnitude of money supply, whatever value it assumes, would have a significant impact on the level of GNP, inflation rate, foreign exchange rate and international trade, among other economic variables.

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Forecasts on Money Supply Through Alternative Methods

(Rs. Billions)

Last Friday of	Forecasts through						
	Box-Jenkins' Method	Decomposition Method	Brown's method	Holt-Winter's method			Regression method
				No Seasonal	Additive Seasonal	Multiplicative Seasonal	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1993-01	3592	3714	3630	3655	3610	3609	3625
1993-02	3699	3893	3746	3777	3741	3752	3750
1994-03	3752	4016	3861	3899	3815	3796	3881
1994-04	3871	4202	3977	4021	3949	3941	4018
1994-01	3947	4369	4093	4142	4046	4044	4159
1994-02	4094	4580	4208	4264	4177	4192	4306
1994-03	4209	4724	4324	4386	4251	4227	4457
1994-04	4336	4942	4440	4508	4385	4377	4614
1994-01	4447	5140	4555	4630	4482	4480	4777
1994-02	4537	5367	4671	4752	4613	4631	4946
1995-03	4604	5557	4787	4874	4687	4659	5120
1995-04	4764	5814	4902	4996	4821	4813	5301