FORECASTING THE BARBADOS MONEY SUPPLY

by

Kevin Greenidge

and

Wendell Mc. Clean

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Kevin Greenidge
Economist
Research Department
Central Bank of Barbados
P.O. Box 1016
BRIDGETOWN

and

Wendell McClean
Senior Lecturer
University of the West Indies
Cave Hill Campus
Cave Hill
ST. MICHAEL

Correspondence Address: Kevin Greenidge, Research Department Central Bank of Barbados, P.O. Box 1016, Bridgetown, Barbados, West Indies. Tel: (246) 436-6870: Fax (246) 427-1431

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Abstract

The purpose of this paper is to provide an adequate forecasting method for the money supply in the Barbadian economy. This would assist the Central Bank in making decisions on monetary intervention. The performance of ARIMA and vector auto-regressive (VAR) forecasting models are investigated, along with combinations of these models. The results of this study suggest that there are reasonable options available for obtaining reliable forecasts of the Barbados money supply. Our findings indicate that seasonal factors and interest rate effects should be comprehended within the forecasting model. We accomplished this through a combination forecasting procedure in which seasonal effects are captured by an ARIMA model and interest rates are introduced through a VAR, as exogenous variables.

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1. Introduction

Economic Theory suggests that, in a small open economy with a fixed or exogenously determined exchange-rate regime, the nominal money stock is an endogenous variable beyond the control of the Central Bank. In such a setting, the money market is demand centered and monetary disequilibrium is predominantly resolved by the rapid adjustment of the actual nominal stock of money to its desired level. In these circumstances, any action by the Central Bank that infuses (effuses) high-powered money into (from) the money market would ultimately impact only upon the balance of payments.

Since July 5, 1975, the value of the Barbadian dollar has been fixed relative to the United States dollar at BDS$2:US$1. Prior to this date, the Barbadian dollar was tied to the Pound Sterling, at a par value of BDS$4.80:£1. Hence, in a Barbadian context monetary policy impacts predominantly on the balance of payments. Accordingly, a forecast of the money supply could assist the Central Bank in evaluating the impact of such an intervention, on the balance of payments.

In this study, we investigate the performance of ARIMA, and vector auto-regressive (VAR) forecasting models. The study has been organized as follows: In the next section, ARIMA models of the money supply are presented. VAR models oriented towards money market considerations are presented in section 3. We report results obtain by combining univariate and multivariate forecasts, in section 4. The study concludes in section 5 with some summary remarks.

2. ARIMA Models

As a first step in the construction of the ARIMA models, we investigated the stationarity properties of the money supply and several transformations thereof. The results of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests indicated that the difference of the money supply, D(MS), the difference of the log of the money supply, D(LMS), the seasonal difference of the money supply,

difference following deseason...

D(MS,0,4), and the seasonal difference of the log of the money supply, D(LMS,0,4) are stationary. We then followed standard search procedures, using Econometrics Views, to construct ARIMA models for the above mentioned stationary series pertaining to the money supply. The models based on the first difference and the seasonal difference of the money supply failed some of the diagnostic checks. The null hypothesis of normality was rejected for both of these models. The F-statistic on the ARCH test of the DMS model indicated a significant degree of heteroskedasticity. A visual inspection of a plot of the residuals supported this finding. The D(MS,0,4) model failed the Chow forecast test. Therefore, the DMS and D(MS,0,4) models were rejected. Both of these models were estimated over the period 1969:2 - 1991:4 and the following results were obtained

$$DMS = \underset{(3.4288)}{5609.04} - \underset{(3.693)}{0.4336}AR(6) + \underset{(2.962)}{0.3761}AR(8) + \underset{(1.839)}{0.2071}MA(3) - \underset{(-2.036)}{0.2388}MA(4)$$

R^2	0.2318	*Akaike info criterion*	19.52775	*D-W*	2.2574
$\bar{R}^2$	0.1961	*Schwarz criterion*	19.6655	*Chow Forecast[F]*	1.3529
ARCH[F]	1.3747	*Breusch-Godfrey (LMSC)*	0.4491	*Norm*[χ^2(2),*Jarque-Bera*]	107.26

$$)(MS,0,4) = \underset{(5.356)}{31078.1} + \underset{(32.87)}{0.9479}AR(1) - \underset{(-2.763)}{0.3514}SAR(4) - \underset{(-21.45)}{0.8913}MA(4)$$

^{2}	0.7386	*Akaike info criterion*	19.4571	*D-W*	2.5216
^{2}	0.7296	*Schwarz criterion*	19.5674	*Chow Forecast[F]*	9.8711
RCH[F]	2.5216	*Breusch-Godfrey (LMSC)*	0.53774	*Norm*[χ^2(2),*Jarque-Bera*]	11.8273

The two models based on the logarithms of the money supply, D(LMS) and D(LMS,0,4), passed all of the diagnostic tests. The D(LMS) model was estimated over the period 1967:2 to 1991:4 and the following results were obtained

$$D(LMS) = \underset{(16.79)}{0.0273} - \underset{(-2.82)}{0.1488}MA(1) - \underset{(-13.95)}{0.7376}MA(14) + \underset{(2.456)}{0.2265}SMA(4)$$

R^2	0.4155	*Akaike info criterion*	-5.8844	*D-W*	1.9762
$\bar{R}^2$	0.3971	*Schwarz criterion*	-5.7795	*Chow Forecast[F]*	1.6681
Norm[χ^2(2)]	0.851012	*Breusch-Godfrey (LMSC)*	0.50972	*ARCH[F]*	0.0479

The results obtained for the D(LMS,0,4) model, estimated over the period 1969:2 to 1991:4, are as follows

$$D(LMS,0,4) = \underset{(9.651)}{0.1078} + \underset{(16.16)}{0.9823}AR(1) - \underset{(-13.86)}{0.8885}AR(4) + \underset{(11.07)}{0.7518}AR(5) - \underset{(-26.49)}{0.8755}MA(8)$$

R^2	0.7576	*Akaike info criterion*	-5.9808	*D-W*	2.0601
$\bar{R}^2$	0.7463	*Schwarz criterion*	-5.8429	*Chow Forecast[F]*	1.3529
Norm$[\chi^2(2)]$	0.8231	*Breusch-Godfrey (LMSC)*	0.22832	*ARCH[F]*	0.0781

Dynamic out-of-sample forecasts were generated for the period 1992:1 to 1995:4 using the two preferred models. As shown in Table 1, the forecasting performance of the D(LMS) were substantially better than that of the D(LMS,0,4) model.

3 VAR MODELS

Inspired by the work of Sims (1980), VARs have become popular among economists, during the last decade. VARs have been used successfully to forecast systems of interrelated time series variables. They are well suited to forecasting variables where each variable helps forecast other variables. The best estimator of each equation in a VAR is ordinary least squares. The mathematical form of a VAR is

$$y_t = \sum_{i=1}^{N} A_i y_{t-i} + Bx_t + \varepsilon_t$$

Where: y_t is a vector of endogenous variables,
x_t is a vector of exogenous variables,
$A_1, \ldots, A_N$ and B are matrices of coefficients,
ε_t is a vector of innovations that are correlated with each other but uncorrelated with their own lagged values and uncorrelated with y_{t-1} and x_t.

Economic theory suggests that the money supply and the arguments of the money demand function constitute a set of variables that could be included in a VAR model, for forecasting the money supply. Hence, as a point of departure, we considered a VAR comprising the logarithms of: the money supply (MS), the consumer price index (CPI), the real value of debits to demand deposit accounts held with commercial banks (RDDD)[1], the nominal interest rate on three-month time deposits (R1). Testing at the 1% level, the ADF and PP tests indicated that all of these variables are stationary in the first difference of both the levels and the logs.

We, therefore, tested for cointegration among these variables, using the Johansen cointegration test. A model selection procedure based on the Schwarz Bayesian Criterion suggested that the VAR should comprise six lags and two cointegration equations, with intercepts (no trend) in the cointegrating equations.

The results obtained by estimating the VAR over the period 1975:4 - 1991:4 indicated that the rate of interest is at least weakly exogenous to our system of equations. Neither of the cointegrating equations entered the interest rate equation significantly, and only one of the lag coefficients of the other variables had a significant "t" statistic. This finding was not surprising because commercial bank interest rates have been highly regulated by the Central Bank, during our sample period. We, therefore, considered alternative model formulations that excluded interest rates from the set of endogenous variables. Our two most successful efforts in this regard involved models that comprised the logarithms: of the money supply, the retail price index, the real transaction variable. The two interest rates variables were included in one of these models, as exogenous variables. The Schwarz Bayesian Criterion indicated that five lags and one cointegration equation with an intercept (no trend) should be included in both VARs.

Using the results thus obtained, dynamic forecasts were generated for the same out-of-sample period as with the ARIMA models. As shown in Table 1, the forecasting performance of all three of the VAR models was better than the ARIMA models. The best performing VAR model was the one that excluded the rate of interest. The model that included interest rates as exogenous variables performed better than the model that included the interest rate as an endogenous variable.

4 COMBINATION OF FORECASTS

The idea of combining individual forecasts in the production of an overall forecast was originally proposed by Bates and Granger (1969). In their paper, they discussed the combination of pairs of forecasts. However the methodology can easily be extended to the combination of several forecasts [Reid, 1969]. If individual forecast of a given variable are unbiased, then the combination forecast obtained by regressing the variable on these forecasts without an intercept will also be unbiased if the sum of the beta coefficients is restricted to unity.

Granger and Romanathan (1984) have argued that biased forecast may also be successfully combined, by fitting the model

$$x_t = \alpha + \beta_1 f_{1t} + \beta_2 f_{2t} + \ldots + \beta_k f_{kt} + e_{ct}$$

without restricting either α to be zero or the β_i to sum to unity. This model is fitted by least squares

[1] "Debits on demand deposits" was chosen as a proxy for real money-using transactions, because official quarterly data on GDP are not available for the Barbados economy.

to the available historical record, and then projected forward to derive the required composite forecast.

We adopted this approach to generate combination forecasts. Six combination forecasting models were estimated each utilising information from one of the two preferred ARIMA and one of the three VAR models, respectively. We regressed the actual level of the money supply on the respective forecast combination, for the period 1967:1 to 1991:4.

These equations were then used to forecast the money supply, over the period 1992:1 to 1995:4. All the combination models out-performed the individual models. Our results (table 1) suggest that, among the models considered, the combination model derived from on the VAR with exogenous interest rates and an ARIMA model based on the seasonal difference should be the preferred model. Figure 1 contains the out-of-sample forecasts for the best model pertaining to each technique.

6. Concluding Remarks

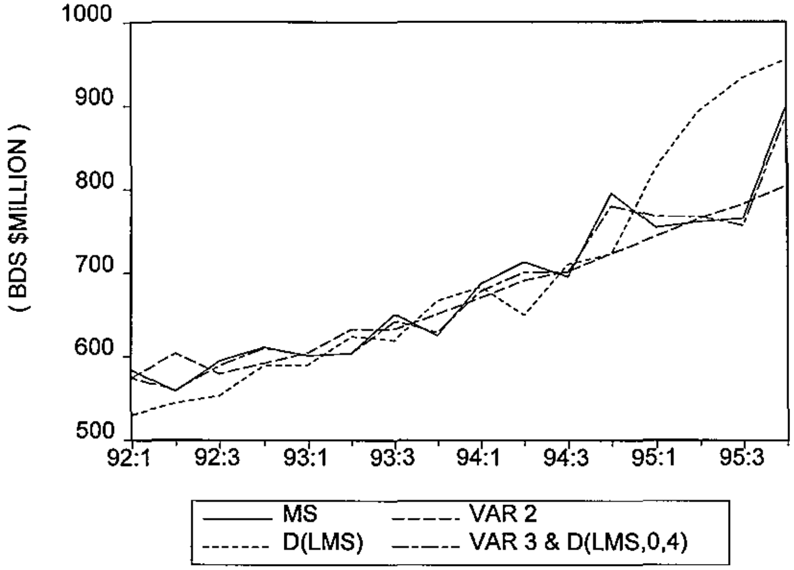
The results of this study suggest that there are reasonable options available for obtaining reliable forecasts of the Barbados money supply. It has been shown that highly accurate forecasts may be obtained from a VAR model comprising a small number of variables. Our findings also indicate that seasonal factors and interest rate effects should be comprehended within the forecasting model. This may be accomplished through a combination forecasting procedure in which seasonal effects are captured by an ARIMA model and interest rates are introduced through a VAR, as exogenous variables.

TABLE 1
Forecast Evaluation

Sample: 1992:1 1995:4 Include observations: 16	ARIMA MODELS		VAR MODELS		
	D(LMS)	D(LMS.0,4)	VAR 1	VAR 2	VAR 3
Root Mean Squared Error	67.11133	89.67151	43.65487	35.28498	37.09971
Mean Absolute Error	51.18299	75.63866	32.22211	25.60478	31.17179
Mean Absolute Percentage Error	7.180331	10.87019	4.466342	3.626223	4.504577
Theil Inequality Coefficient	0.048175	0.061775			
Bias Proportion	0.031040	0.667946			
Variance Proportion	0.403028	0.120942			
Covariance Proportion	0.565932	0.211112			

	COMBINED MODELS					
	VAR1 & D(LMS)	VAR1 & D(LMS,0,4)	VAR 2 & D(LMS)	VAR 2 & D(LMS,0,4)	VAR 3. & D(LMS)	VAR 3. & D(LMS,0,4)
Root Mean Squared Error	9.107196	11.98169	25.26260	16.21627	12.59028	8.397454
Mean Absolute Error	7.254605	10.12141	20.30421	13.42625	10.15285	6.952477
Mean Absolute Percentage Error	1.015476	1.419178	2.852007	1.881170	1.426935	0.970544
Theil Inequality Coefficient	0.006644	0.008736	0.018490	0.011870	0.009187	0.006125
Bias Proportion	0.129449	0.056665	0.085419	0.250839	0.079262	0.155384
Variance Proportion	0.120763	0.018388	0.070274	0.026369	0.108034	0.034766
Covariance Proportion	0.749788	0.924947	0.844306	0.722792	0.812704	0.809851

FIGURE 1
Out-of-Sample Forecast
(The best model of each technique)



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