STRUCTURAL MACROECONOMIC MODELING EXERCISES FOR CORPORATE PLANNING

Carlos C. Bautista*

This paper presents a simple, easy–to–use structural macroeconometric model designed to generate quarterly forecasts of four key macroeconomic variables – the exchange rate, the interest rate, the inflation rate and the GDP growth rate. The model's appeal is the ease by which timely forecasts, based on sound economic principles, can be made. This is important from a corporate planner's perspective especially when macroeconomic events heavily influence the direction of a firm's growth. The model is estimated by ordinary least squares using quarterly Philippine data from 1981:1 to 2000:3. Historical simulations, both static and dynamic, were conducted to gauge the tracking ability of the model.

The first sample application makes a forecast of the four variables for the year 2001 based on the recently concluded EDSA II and assumptions on other exogenous variables: liquidity follows its trend growth; CPSD/GDP = – 4 percent and CA/GDP = 9 percent. The unprecedented discrete movement of the exchange rate from 54.7 to 47.5 pesos per dollar shifts the end–of–year forecast of 2.3 percent GDP growth to 3.1 percent. The second example computes for the 2001 growth rate that is compatible with a government deficit of 225 billion pesos. Growth with this deficit level turns out to be 2.7 percent. Monte Carlo simulations were conducted so that forecast confidence intervals can be obtained.

I. INTRODUCTION

This paper presents a simple, easy–to–use structural macroeconometric model designed to generate *quarterly* forecasts of four key macroeconomic variables – the exchange rate, the interest rate, the inflation rate and the GDP growth rate. The model's appeal is the ease by which timely forecasts, based on sound economic principles, can be made. This is important from a corporate planner's perspective especially when the macroeconomic events heavily influence the direction of a firm's growth. Examples of these firms are those that depend heavily on imported inputs or firms whose sales depend on the income elasticity of demand. For the former, the exchange rate is the variable to be watched by the planners while for the latter, GDP growth would be closely monitored and anticipated for planning purposes.

The model in this paper is a descendant of an annual dynamic IS–LM model that has been used as the core model of several

---

* Professor, College of Business Administration, University of the Philippines. The author benefited from discussions with participants in a lecture seminar held 1 Feb 2001. The comments of an anonymous referee are also gratefully acknowledged. The author is however solely responsible for all errors in the paper.

collaborative studies conducted by the author (see for example, Bautista et al., 1995). The novelty in this exercise is the use of quarterly data. Section 2 discusses the theoretical specification and section 3 describes the data, the econometric estimation and historical simulation. The final section presents a sample application that provides some forecasts for the year 2001 based on assumptions on the exogenous variables and anchored on the recently concluded EDSA II events.

II. MODEL FRAMEWORK

This version of the model maintains the Keynesian structure of the previous versions and makes use of the portfolio approach to exchange rate determination in modeling the asset markets.[1] Output is determined on the demand side, but instead of using the national income identity as in most structural models, output is determined by an IS function expressed in percentage change. This drastically simplifies the structure of the model.

The goods market is described by a downward sloping IS function in the interest rate–output plane. The model's version of the IS function states that output (GDP) growth is positively influenced by the level of the real exchange rate and negatively by the real interest rate. It also responds to the level of government deficit positively, all else equal. These relationships are shown in equation (1):

$$\hat{q} = \hat{q}\left(r, \frac{ep^*}{p}, \frac{CPSD}{q} \right) \qquad (1)$$

A '^' over a variable indicates the variable's percent change and is computed as the first difference of its logarithm. The last variable shows that the deficit is scaled by the GDP level that conveniently describes an important policy parameter in the Philippine policy arena – the deficit to GDP ratio. Variable definitions are shown in the Appendix.

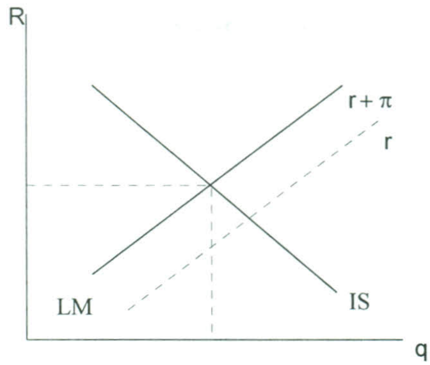
Equation (2) describes money market equilibrium and is essentially an LM function. The real interest rate, defined as $r = R - \pi^e$, serves to clear the market. The LM function shows that the real interest rate is affected by the depreciation rate, the output level and the real money supply.

$$R = r\left(q, \hat{e} - \pi^{\varepsilon}, \frac{M}{p} \right) + \pi^{\varepsilon} \qquad (2)$$

For given levels of real money supply, government deficit, expected inflation and depreciation rate, equations (1) and (2) determine equilibrium aggregate demand and nominal interest rate for the economy. Graphically, this is shown as the intersection of the IS and LM functions in Figure 1 below:

[1] The original model is described in Bautista (1989).

Figure 1

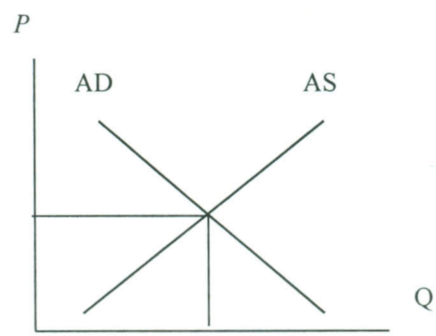


The IS–LM framework determines equilibrium output given a horizontal aggregate supply curve, i.e., the price level is assumed fixed and shows the very short run nature of the framework. A price equation such as equation (3) is needed to relax this strict assumption. The resulting upward sloping short–run aggregate supply equation (in percentage change), shows the short to medium run nature of the model. The function shows that the inflation rate is directly affected by output growth and the nominal depreciation rate.

$$\hat{p} = \hat{p}(\hat{e}, \hat{q}) \tag{3}$$

Equation (3) together with equations (1) and (2) which determine aggregate demand, solve for the equilibrium price and output. Figure 2 illustrates this.

Figure 2



The rate of nominal depreciation, specified in equation (4), summarizes the extent of activity in the foreign exchange market. The equation incorporates portfolio substitution effects through the rate of interest, effects of real activity through the output variable, and the level of the current account balance.

$$\hat{e} = \hat{e}\left(R, \hat{q}, \frac{CA}{q}\right) \tag{4}$$

The last variable is scaled by GDP and can be set as a policy target: the current account to GDP ratio. Note that this completes the description of the economy in highly aggregate terms. Only three markets are explicitly modeled: the goods market, the money market and the foreign exchange market. A fourth market, the domestic asset (bond) market is the fourth market that automatically clears by Walras' Law and need not be modeled explicitly.

III. EMPIRICAL IMPLEMENTATION OF THE MODEL

Data and Estimation

The quarterly data came from various sources. National accounts data are obtained from the National Statistical Coordinating Board (*NSCB*) while monetary, interest rate and exchange rate data can be obtained from the *Bangko Sentral ng Pilipinas* and the Department of Finance. Estimation is for the period 1981:1 to 2000:3.

In the model, growth rates are computed as the first difference of their logarithms and are therefore quarterly rates. The interest rate is also converted into quarterly rates, i.e., $R4 = (1 + R)^{1/4} - 1$. Quarterly real GDP data has a very high seasonal component. To deseasonalize, this variable is allowed to pass through a four-quarter moving average filter. The modeling procedure is also simplified by using the assumption of perfect foresight, i.e., values of expected variables are equal to the actual values. Thus $\pi^e = \pi$. A bust cycle dummy was also used to improve the fit of some of the equations. Based on the boom–bust dating in Bautista (2000), the dummy is turned on for the quarters 1983:1 to 1985:3, 1990:2 to 1993:3 and 1997:3 to 1999:1.

Table 1 presents the final, ordinary least squares estimates of the four equations of the model described in the preceding section. In modeling exercises such as this, a compromise between theoretical precision and empirical feasibility has to be made. One will notice that the estimates deviate from the theoretical specification in a variety of ways. The main reason is the necessity to find the lag structure that can adequately characterize the dynamics of the Philippine economy. Also, it is important to choose the estimates based on the correct signs of the coefficients, the value of the adjusted R^2 and standard errors.

Historical Simulation

The historical simulation tries to gauge the tracking ability of the model. The simulation process solves a set of simultaneous equation system per period. This set is composed of the 4 equations above: the IS equation and the LM equation that together solve for aggregate demand and equilibrium interest rate; the aggregate supply equation and the exchange rate equation that solve for the equilibrium price level and exchange rate.

Figure 3 shows static historical simulations describing the actual and simulated values of *GDP* growth, inflation rate, nominal interest rate and the depreciation rate. From the diagrams, one can see that the fitted or simulated values closely follow the actual values including

Table 1
Ordinary Least Squares Estimates of Equations 1 – 4

Dependent: DLOG(E)

Variable	Coefficient	Std. Error	Sample: 1982:4 2000:2	
Constant	0.022	0.028	R–squared	0.248
DLOG(QA4(–2))	2.667**	1.470	Adjusted R–squared	0.165
DLOG(QA4(–3))	–2.244	1.360	F–statistic	2.975
E(–1)*CA$(–1)/(PA4(–1)*QA4(–1))	–0.272	0.168	Prob(F–statistic)	0.009
DLOG(PA4)	0.980*	0.439	Durbin–Watson stat	1.847
R4(–1)	–1.395**	0.705		
D1	0.048*	0.018		
DLOG(E(–1))	–0.175	0.121		

Dependent: PA4

Variable	Coefficient	Std. Error	Sample: 1981:4 2000:3	
Constant	–0.761*	0.148	R–squared	0.988
QA4	0.000005*	0.000001	Adjusted R–squared	0.987
E	0.011*	0.003	F–statistic	1906.329
TREND	0.029*	0.002	Prob(F–statistic)	0.000
			Durbin–Watson stat	0.113

Dependent: DLOG(QA4)

Variable	Coefficient	Std. Error	Sample: 1982:2 2000:3	
Constant	0.022*	0.002	R–squared	0.706
DLOG(E(–1))	0.018**	0.012	Adjusted R–squared	0.680
DLOG(PA4)	–0.272*	0.046	F–statistic	26.844
CPSD(–1)/(PA4(–1)*QA4(–1))	0.193**	0.114	Prob(F–statistic)	0.000
CPSD(–2)/(PA4(–2)*QA4(–2))	–0.177	0.108	Durbin–Watson stat	1.017
D1	–0.007*	0.002		
R4(–1)	–0.152*	0.069		

Dependent: R4

Variable	Coefficient	Std. Error	Sample: 1982:2 2000:3	
Constant	0.060*	0.030	R–squared	0.819
R4(–1)	0.577*	0.085	Adjusted R–squared	0.806
LOG(M3/PA4)	–0.004**	0.002	F–statistic	61.520
DLOG(QA4(–1))	0.204**	0.104	Prob(F–statistic)	0.000
DLOG(E)	0.031*	0.012	Durbin–Watson stat	2.195
DLOG(PA4(–1))	0.299*	0.058		

*Significant at 5%
** Significant at 10%
Note: DLOG() stands for the first difference of the logarithm of the variable in parenthesis – the percentage rate of change of the variable.

most of the turning points.[2] Figure 4 shows the dynamic simulation results beginning 1992. This exercise shows how the model would have performed had it been used to forecast the variables during that period.

Application: Forecasts for 2001

As an application, the model is used to forecast the values of the variables for the year 2001. The values of the variables for the last quarter of 2000 are known as of this writing except for the GDP growth rate. This is set to a value between 3.8 and 4.0 percent expected by most. There are 4 exogenous variables nominal money supply (M3), the bust cycle dummy (D1), the consolidated public sector deficit (CPSD) and the current account in dollar terms (CA$).

M3 is allowed to follow a path that depends on its past value and a deterministic time trend. D1 is turned on for the forecast period. The current account to GDP ratio was assumed to be constant at its latest actual value of 0.09. The CPSD/GDP ratio is also set to its latest actual value of 0.04.

An interesting application has something to do with the recently resolved crisis. During the crisis, the economy experienced an unprecedented discrete movement of the peso from 54.7 pesos per dollar in January 18 to 47.5 in January 19. This is an appreciation of 13.2 percent in one day, as a result of the defection of the military to the opposition, signaling the resolution of the crisis. One can feed these numbers into the model as values of the exchange rate for the first quarter of 2001 to see the short–run effects of an appreciation alone on the growth rate, inflation, interest rate level and future values of the exchange rate. The forecast results are shown in Table 2. This discrete movement of the exchange rate shifts the end–of–year forecast of 2.3 percent GDP growth to 3.1 percent.

A second example is also shown in Table 2. In this simulation, the CPSD level of 225 billion pesos that is expected by the government is fed into the model. This translates to 6.5 percent of GDP compared to 4 percent in the previous simulations. The result is a lower growth rate of 2.7 percent.

---

[2] Thus, one can say that the model tracks the Philippine economy reasonably well. The tracking prowess of a simulation model can alternatively be determined by computing for simulation statistics: *RMSPE, RMSE,* inequality coefficients (*U*), etc., but is not done in this paper.

Table 2
Forecast Results: Fourth quarter 2000 to fourth quarter 2001

	GDP growth	Inflation rate	91-day T-bill rate	Exchange rate
18 January 2001 exchange rate = 54.77				
2000.4	3.85	6.56	13.59	50.07
2001.1	1.72	7.66	12.43	54.73
2001.2	3.27	7.12	11.96	54.63
2001.3	2.59	6.61	10.30	55.01
2001.4	2.34	6.25	9.71	57.10
19 January 2001 exchange rate = 47.50				
2000.4	3.85	6.56	13.59	50.07
2001.1	4.05	5.57	10.49	47.56
2001.2	2.02	5.50	9.09	49.18
2001.3	2.84	5.36	9.25	50.62
2001.4	3.07	4.62	9.27	51.25
CPSD level for end 2001 = 225 billion pesos 19 January 2001 exchange rate = 47.50				
2000.4	3.85	6.56	13.59	50.07
2001.1	2.30	5.37	10.43	47.37
2001.2	1.84	5.29	8.44	49.03
2001.3	2.96	4.99	8.68	49.91
2001.4	2.69	4.45	8.94	51.25

IV. CONFIDENCE BOUNDS ON THE FORECAST

In most cases, the user of the forecast would want to determine how reliable the forecast results are. It should be pointed out that the point forecasts of the previous section in effect assume that the estimated equations hold exactly over the forecast period. In practice, errors in forecast, big or small, are the rule rather than the exception. Hence one would want to know how much one could confidently say that the forecasts are well within reasonable error intervals. The wider the error bounds are, the less reliable is the forecast. An example of the computation of the confidence band is done in this section using the results of the second simulation of Table 2 and for a forecast period extended to 2004.

To compute for these error bounds, the model is repeatedly solved with a random error term set in each equation. The standard deviation of the error term is estimated from historical data. With this introduction of uncertainty in the model, the distribution of each endogenous variable at every point forecast can be computed easily. The simulation of these distributions is done through a Monte Carlo procedure where the model is repeatedly solved a thousand times using a random number generator for the unknown innovations. The forecast mean and standard deviation results are shown graphically in Figure 5. As expected, the results indicate that error bound is relatively narrower for level variables like the exchange rate level compared to the log-differenced variables – the inflation rate and the growth rate.

Figure 3
Static Historical Simulation

Figure 4
Dynamic Historical Simulation

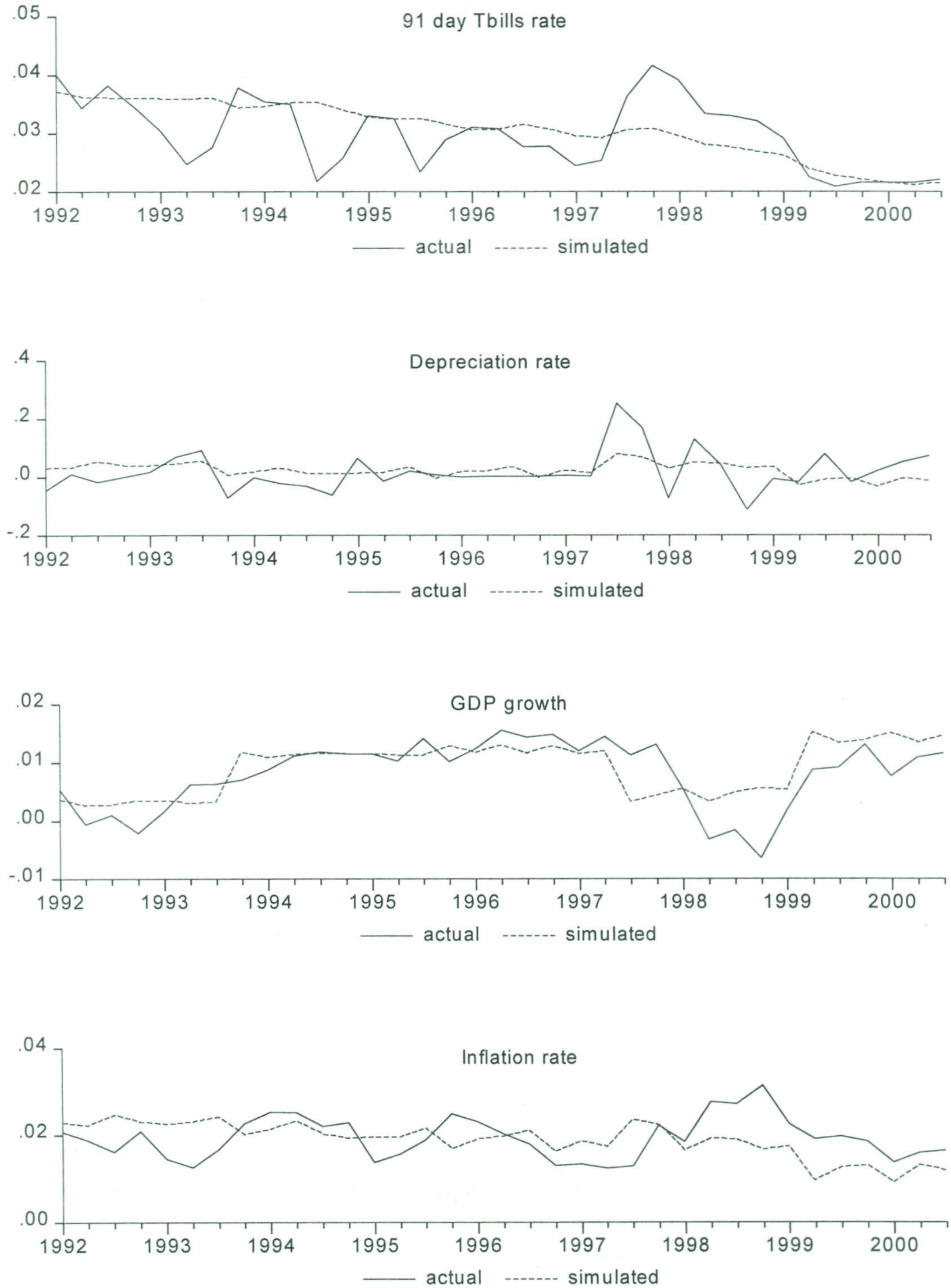
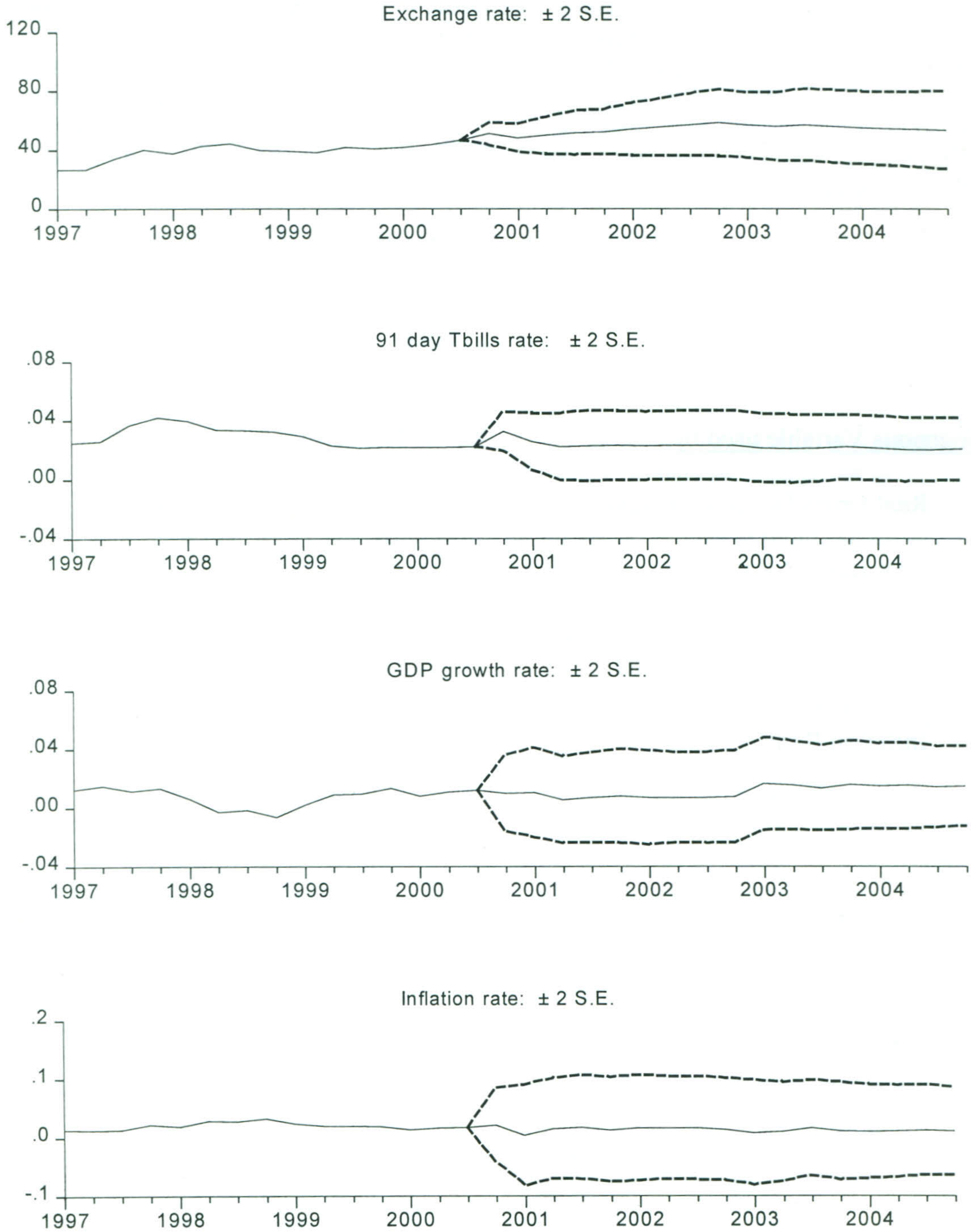


Figure 5
Stochastic Simulation



REFERENCES

Bautista, C. 2000. *Boom–bust cycles and crisis periods in the Philippines: A regime–switching analysis*. Discussion Paper no. 00–09, School of Economics, University of the Philippines.

Bautista, C. 1989. *An annual macroeconometric model of the Philippines*. Discussion Paper no. 89–12, School of Economics, University of the Philippines.

Bautista, C., Ybañez, R., & Agulto, G. 1995. The behavior and performance of the Philippine commercial banking industry, 1980-1994. In R. Rodriguez (Ed.), *The Philippine financial services industry: Prospects and challenges in the next decade*: 13-33. Quezon City: University of the Philippines Press, UP Center for Integrative and Development Studies, and the UP College of Business Administration.

Appendix
List of Variables

Endogenous Variable used in	Model Framework	Table 1
Real Gross Domestic Output (*GDP*)	q	*QA4*
Nominal Interest Rate	R	*R4*
Real Interest Rate	r	
Nominal Exchange Rate	e	*E*
General Price Level (*GDP* deflator)	p	*PA4*
Nominal Depreciation Rate	$\hat{e}$	
GDP growth Rate	$\hat{q}$	
Inflation Rate	$\hat{p}$	
Real Exchange Rate	ep^*/p	

Exogenous/Policy Variables in	Model Framework	Table 1
Nominal Money Supply (total liquidity)	M	*M3*
Current Account Balance in dollars	CA	*CA$*
Consolidate Public Sector Deficit	$CPSD$	*CPSD*
Foreign Price Level	p^*	
Bust Cycle Dummy	–	*D1*