The Bangko Sentral's structural long-term inflation forecasting model for the Philippines

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Abstract

Because of the forward-looking nature of inflation targeting, successful implementation of the framework entails good forecasting ability for the monetary authorities. Toward this end, the BSP has exerted considerable efforts at developing its econometric models.

In order to provide monetary authorities with a clearer indication of the outlook on inflation over the policy horizon of two years, the BSP has been developing an annual macroeconomic model for inflation forecasting and policy analysis. The objective of the project is to provide the BSP a quantitative tool to forecast headline and core inflation rates one to two years into the future; to analyze the impact on headline and core inflation of key factors such as the exchange rate, world oil price, interest rates, wages, government borrowing and other relevant variables; to determine the effectiveness of different channels and instruments of monetary policy, with special attention to the impact of changes in the BSP's short-term borrowing and lending rates, which are the BSP's policy levers; and to guide the monetary authorities in their decision making process pertaining to the appropriate policies for the attainment of the BSP's primary mandate of promoting price stability conducive to balanced and sustainable economic growth.

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1. Introduction

Because of the forward-looking nature of inflation targeting, successful implementation of the framework entails good forecasting ability for the monetary authorities. Toward this end, the BSP has exerted considerable efforts at developing its econometric models. The BSP has already in place two short-term inflation forecasting models, both developed under the supervision of Dr. Roberto S. Mariano of the University of Pennsylvania. These models have good

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tracking abilities and are continuously being improved and updated. In order to provide monetary authorities with a clearer indication of the outlook on inflation over the policy horizon of two years, the BSP has tapped Dr. Mariano anew to develop an annual macroeconomic model for inflation forecasting and policy analysis.

The objective of the project is to construct a structural long-term annual macroeconometric model of the Philippine economy that will serve as a quantitative tool of the BSP to forecast headline and core inflation rates one to two years into the future; to analyze the impact on headline and core inflation of key factors such as the exchange rate, world oil price, interest rates, wages, government borrowing and other relevant variables; to determine the effectiveness of different channels and instruments of monetary policy, with special attention to the impact of changes in the BSP's short-term borrowing and lending rates, which are the BSP's policy levers; and to guide the monetary authorities in their decision making process pertaining to the appropriate policies for the attainment of the BSP's primary mandate of promoting price stability conducive to balanced and sustainable economic growth.

A complete version of the annual structural model of the Philippine economy has already been estimated. The model consists of a simultaneous system of 38 estimated equations, with the behavioral equations estimated, whenever possible, using annual data over 1971-1999, and 40 identities. The equations are grouped into seven major blocs, as follows:

Table 1. Count of Equations in the Model

BLOC	Behavioral	Identities	Total
Expenditure	9	10	19
Monetary	9	11	20
Fiscal	4	6	10
Price	12	6	18
Labor	1	3	4
Production	1	1	2
BOP	2	3	5
Total	38	40	78

In order to enhance the model's appropriateness for inflation forecasting and monetary policy simulation exercises, special attention has been devoted in the model specification to:

•   modeling in greater detail the determination of prices in the system;

- incorporating explicitly the channels through which the impact of changes in the BSP's policy levers are transmitted in the monetary sector of the model; and

- tracing the transmission mechanisms from the monetary sector to core and headline inflation, wages, employment and output.

Thus the model specifies in detail the linkages between the monetary sector and the other sectors of the economy and the channels through which monetary policy actions impact on major economic variables of interest.

This report presents the equations of the BSP's macroeconometric model of the Philippines and forecasts and scenario simulations based on the working version of the model. In specifying the model, a fine balance between realism and manageability in the maintenance of the model has been maintained. The specification of the model must be realistic and rich enough to represent the main forces involved in the demand and supply sides of inflation in the Philippines and to allow analysis of the impact of interest rate changes (and external factors as well) on inflation and growth in the real sector of the economy. Such a specification necessarily requires a demanding database to support the estimation and simulation of the model. The data requirements, though substantial, have been controlled within manageable limits for purposes of maintenance and future use of the model.

The main characteristics of the model, its major components, and its structure are discussed in the next section. This report then provides a validation of the constructed model through simulations and a sensitivity analysis of the model over 1987-2001. This is done through dynamic simulations of the model to validate model projections under alternative scenarios or policy measures.

2. Main characteristics of the model

2.1 Major blocs in the model

The model partitions the Philippine economy into seven major blocs: prices, expenditures, production, balance of payments, employment, monetary sector and public sector.

In this model, the demand side (expenditures) and supply side (production) of the real sector interact to determine aggregate GDP and the aggregate price level. On the demand side, the major endogenous variables are private and public consumption expenditures, private and public investment expenditures, merchandise exports, and merchandise imports. On the supply side, the model explains aggregate GDP in terms of capital utilization and labor employment (in full-time equivalent). In the employment bloc, wages are explained through a
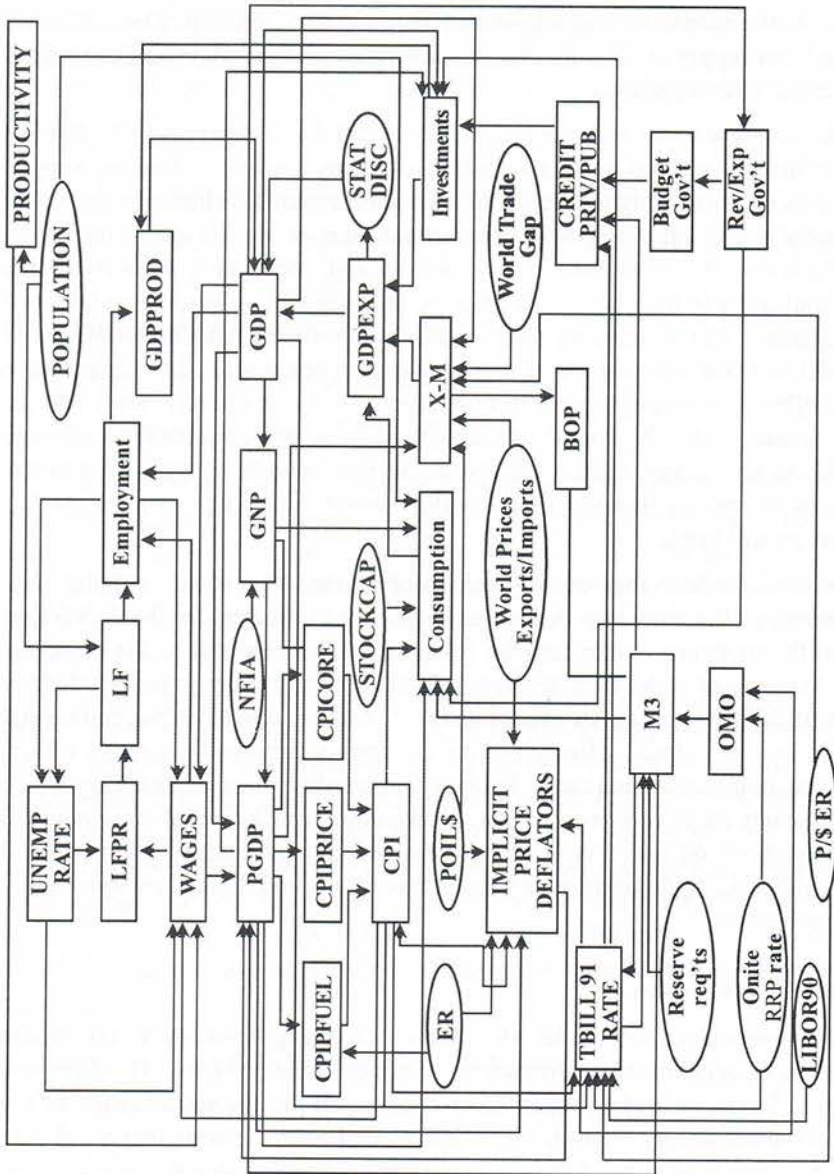
Figure 1. BSP Inflation Macromodel Flowchart

Phillips curve. Labor force is determined by the labor force participation rate (treated endogenously in the model) and the population 15 years and older in the Philippines. On the labor demand side, for a given value of capital stock, labor utilization is derived from the optimizing behavior of firms in the economy and depends, in the model, on real wages and output in the economy. The difference between labor supply and labor utilization generates the unemployment rate, which in turn affects the wage rate.

The monetary sector endogenizes money demand and money supply. Interest rates are then determined by the interaction of money demand and money supply. BSP policies on the overnight interest rate on reverse repurchase transactions (RRPs) affect money supply through their direct effects on open market operations of the BSP (which directly affect base money) and through their indirect effects on the money multiplier (which is directly affected in the model by lending and deposit interest rates). BSP policies on reserve ratio requirements have direct effects in the model on some components of BSP open market operations; they further have indirect effects on money supply through their effects on interest rates. On the money demand side, the impact of changes in these BSP policies filter through their effects on interest rates. The overnight interest rate on RRPs also enters directly in the money demand equation (the re-normalized equation for the 91-day treasury bill rate).

The model reflects the two-way linkage of the monetary sector with the other components of the economy in various ways. In particular, feedback linkages between the monetary sector and the price sector are essential to the complete model. In the equation for the GDP price deflator, monetary policy impacts indirectly on the GDP deflator through its impact on labor costs per unit of output and capital costs per unit of output. Money supply, as a proxy for wealth, directly affects private consumption expenditures. It also affects credit to the private sector, which in turn impacts on private investments. In the other direction, real activity (GDP) and expectations on inflation directly affect real money demand. Exports and imports affect the trade balance and the BOP accounts and, hence, reserve money and money supply.

2.2 Price determination

As a forecasting tool under an inflation targeting framework, the model provides more detail in the determination of prices in the economy. Headline and core CPI inflation are treated separately in the model. In the specification of the model, food and energy prices have been excluded from the computation of core inflation. Specifically, the following relationship is used to calculate the core component of *CPI*:

$$CPI = .1840\, CPIFOOD + .0574\, CPIFUEL + .7586\, CPICORE$$

The weights are based on the 1994 combined weights of rice (11.8171 percent), corn (1.2253 percent) and fruits and vegetables (5.3541 percent) for *CPIFOOD*. For *CPIFUEL*, the weights used correspond to fuel, light and water. Ideally, we should be using gas-lpg (0.6829 percent), kerosene (0.4014 percent), oil-gasoline-diesel transportation (0.7163 percent), and other lubricants transportation (0.1240 percent). However, no historical series is available for this subset. Hence, we have to settle for the aggregate sector of fuel, light and water for the data and weight for *CPIFUEL*.

2.3 The monetary sector and the transmission mechanism

The monetary sector in the model explicitly incorporates BSP's policy levers, namely:

- the overnight interest rate on RRPs
- statutory reserve ratio requirements
- liquidity reserve ratio requirement.

The specification of the model establishes the transmission mechanisms from changes in these policy levers, through open market operations of the BSP and changes in the money multiplier and base money, to consequent changes in core and headline inflation, wages, employment, and output in the economy. This section discusses in greater detail the transmission mechanism from changes in the BSP's policy rates to key sectors in the economy.

Changes in the BSP's reverse repurchase rate (*RONIGHTRRP*) impact on the level of BSP borrowings through Equation 1, which relates the level of BSP borrowings *RRPs* as a proportion of total deposits (*RRPs/TD*) to the difference between the *RRP* rate and the bank lending rate (*RLENDING*), the change in the stock price index (*DLOG(STOCKPRICE)*), and the London interbank borrowing rate (*LIBOR90*). The dummy variable *D96* takes into account the impact of large BSP purchases of foreign exchange in 1996, which contributed to a liquid market and increased the sensitivity of funds to changes in the BSP policy rate. Two other dummy variables have been introduced to account for the impact of the regional financial crisis.

1. $RRPs/TD = f(RONIGHTRRP - RLENDING)^{**}$,

$$[DLOG(STOCKPRICE)]^{**}, \ LIBOR90^{**},$$

$$D96^{**}, \ D97^{**}, \ Y2K^{**}$$

* = significant at 10 percent level
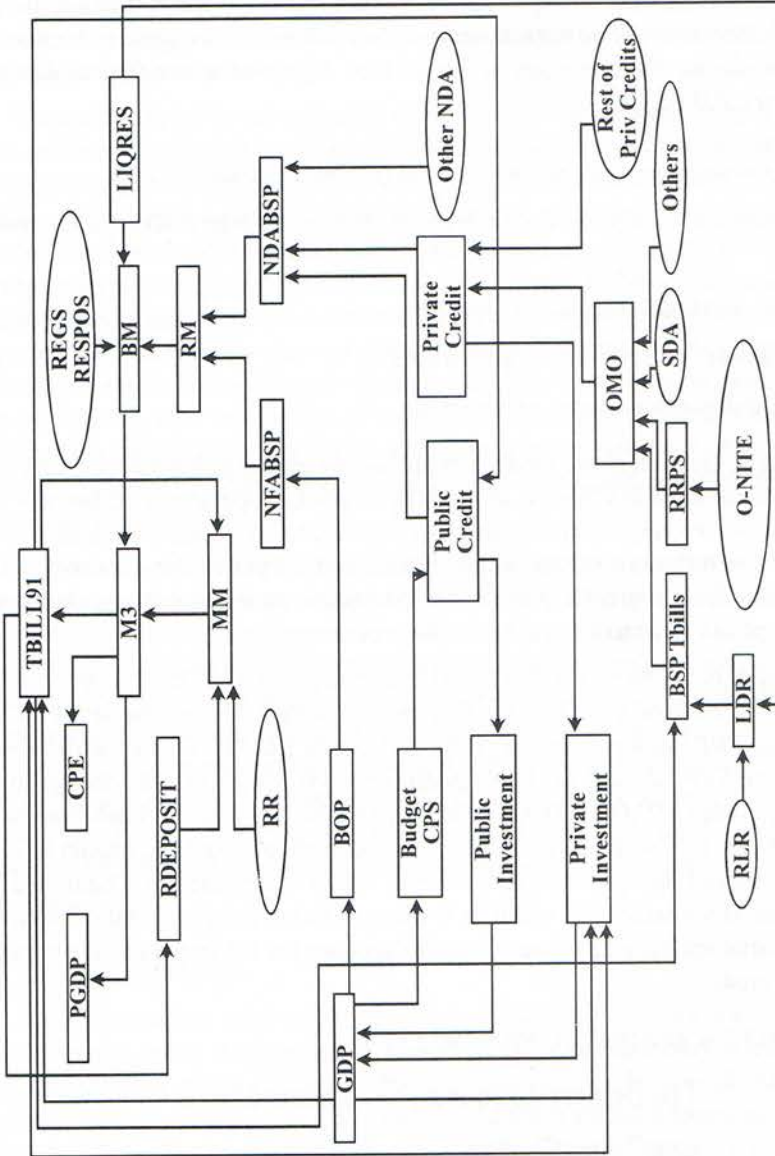** = significant at 5 percent level

Figure 2. BSP Inflation Macromodel-Monetary Sector Flowchart

Given the level of BSP borrowings and other open market operators (*OMO*) instruments, the level of open market operations is then determined through the identity:

2. $OMO = BBILLS + SDA + BSPTBILLS + RRP + OMOTHER,$

where *BBILLS* represents the BSP's issuances of certificates of indebtedness, *SDA* is the level of special deposit accounts, *BSPTBILLS* are the BSP's holdings of Treasury bills, and *OMOTHER* represents the other components of open market operations.

Changes in the *OMO* level impact on the BSP's net domestic asset position (*NDABSP*) through the identity given by equation 3. Changes in the BSP's net domestic asset and net foreign asset (*NFABSP*) position then determine the levels of reserve money (*RM*) and base money (*BM*) according to the identities given by equations 4 and 5:

3. $NDABSP = OMO + NGDEPOSIT + NDABSPOTHER,$

where *NGDEPOSIT* and *NDABSPOTHER* are net government deposits and other components of BSP's net domestic assets respectively.

4. $RM = NFABSP + NDABSP$

5. $BM = RM + LIQRES + REGS + RESPOSITION,$

where *LIQRES*, *REGS* and *RESPOSITION* are liquidity reserves, reserve-eligible government securities, and deficiency in banks' reserve position with the BSP.

The money multiplier (*MM*) is modeled as the result of the interaction of the BSP's policy levers with the behavior of the household and financial sectors. The components of the money multiplier are the currency deposit ratio (CDR), the regular reserve-deposit ratio (*RDR*), and the liquidity reserve-deposit ratio (*LDR*). These are linked by separate equations to their determinants. One equation relates the currency deposit ratio to bank branches per capita, the rate of currency depreciation, the inflation rate, and to a dummy variable that accounts for the impact of the Y2K turnover. Succeeding equations then relate the reserve deposit ratio and the liquidity reserve ratio, respectively, to the regular and liquidity reserve ratios imposed by the BSP. The money multiplier is then determined as

6. $MM = (1 + CDR)/(CDR + RDR + (CASHINVDMB/TD) + LDR + ((REGS + RESPOSITION)/TD)),$

where *CASHINVDMB* is cash in vaults of deposit money banks.

Once the money multiplier and the level of base money are determined, domestic liquidity is determined through the following identity:

7. $M3 = MM \times BM$

The liquidity level then impacts on the 91-day T-bill rate according to Equation 8, which can be thought of as an inverted money demand function. The equation states that the T-bill rate is higher, the tighter the level of real money supply ($M3/PCPI$), the higher the output level $LOG(GDP)$, the higher the inflation rate ($DLOG(PCPI)$, the higher the higher the 90-day Libor rate $LIBOR90$, the higher the BSP's overnight borrowing rate, and the higher the deficit of the national government $BALNG$. Thus, apart from the indirect transmission channel outlined above, there is a direct channel from the BSP's policy rates to the T-bill rate.

8. $TBILL91 = f\{[LOG(M3(-1)/PCPI(-1)/100]^*, \ LOG(GDP),$
$$[(DLOG(PCPI) \times 100)]^{**}, \ RONIGHTRRP^{**}, \ LIBOR90^{**},$$
$$BALNG^{**}\}$$

Changes in the T-bill rate are then carried over to changes in the real sector through private investment (Equation 9), where IP is private investment, $PCPIINF$ is the inflation rate, measured as the percentage change in the consumer price index, $BOPCAPBALN\$$ is the capital accounts balance, measured in US\$, $CREDITPRIV$ measures total credit to the private sector, $PGDP$ is the implicit price index for GDP, and ER is the peso-US dollar exchange rate.

9. $LOG(IP) = f\{DLOG(GDP(-1)^{**}, \ [(TBILL91(-1) - PCPIINF(-1)]^*$
$$BOPCAPBALN\$(-1)^{**}, \ (CREDITPRIV/PGDP)^{**},$$
$$(ER/PGDP)^{**}\}$$

In addition to the interest rate channel, monetary policy feeds in to consumption and investment demand through real money balances and through the level of credit to the private sector. Consumption and investment demand then feed in to the level of aggregate demand and thus to GDP. GDP then feeds in to labor demand, which interacts with labor supply to determine the rate of unemployment ($UNEMPRATE$). The unemployment rate influences changes in the non-agricultural compensation index ($COMPNAGRI$, with corresponding growth measure $COMPNAGRIPCT$), through a Phillips curve relationship (Equation 10).

10. $COMPNAGRIPCT = \{UNEMPRATE^{**}, \ PGDPINF(-1)^*\}$
$COMPNAGRI = COMPNAGRI(-1) \times (1 + (COMPNAGRIPCT/100))$

where $PGDPINF$ is the rate of change of the implicit price index for GDP.

To the extent that monetary policy is able to influence the real rate of interest in the short-run, then there is a further impact on prices through the implicit

price index for capital formation (*PIFC*). An increase in the real rate of interest decreases the demand for new capital, and therefore dampens the rate of change in the implicit price index for capital. Other factors that significantly influence the price of capital are the price of capital imports (*PMCAP*), the level of the national government deficit relative to GDP, the real interest rate, and the rate of change of fuel prices (*DLOG(PCPIFUEL)*).

11. $DLOG(PIFC) = f\{DLOG(PMCAP)^{**}, [BALNG\_NEW(-1)/GDPN(-1)]^{**},$
$$[DLOG(PGDP(-1)]^{**}, (TBILL91 - PGDPINF)^{**},$$
$$DLOG(PCPIFUEL)^{**}, D99^{**}\}$$

Finally, Equation 11 determines the GDP implicit price index as a function of the costs of the various production inputs. As noted previously, the change in the GDP price index is modeled in terms of a cost-push relationship, with changes in unit labor costs and unit capital costs driving changes in the average price level. In addition to these factors, the openness and dependence of the Philippine economy on fuel imports is recognized through the inclusion of the cost of the price of imported oil in the price equation.

12. $DLOG(PGDP) = f\{[DLOG(COMPNAGRI \times NEMPFTE/GDP)]^{**},$
$$DLOG(PIFC \times KAPITAL/GDP)^{**},$$
$$DLOG(ER \times POIL\$ \times MFUEL/GDP)^{**}, D84^{**}, D92^{**}\}$$

where *NEMPFTE* is the level of employment, measured in full-employment equivalent units, *KAPITAL* is capital stock, *POIL$* is the average import price of oil, *MFUEL* is total fuel imports in real terms, and *D84* and *D92* are dummy variables for the respective years.

Considerable attention is given in the BSP macroeconometric model on the feedback from the GDP implicit price index and other price variables to the various consumer price measures. As mentioned previously, these measures include *CPIFOOD, PCPIFUEL, CPICORE* and *CPI*.

3. In-sample forecasting performance of the model

This section assesses the model's forecasting performance over parts of the sample period and analyzes the model's simulated response to an exogenous change in the BSP's policy interest rate.

The following table reports the results of a static simulation of the model over the period 1987 – 2001. The forecasting performance of the model is evaluated using the following statistics:

1. Mean absolute error: $\text{MAE} = (1/n)\Sigma\,|P - A|$

2. Mean absolute percent error: $\text{MAPE} = (1/n)\Sigma\,|(P - A)/A| \times 100$

where:

A = actual value
P = predicted or simulated by the model
n = number of periods covered by the simulation.

The first summary error statistic is sensitive to the units of the variable while the second is unit-free. If the performance of different equations is to be compared, then MAPE is generally more useful. However, there are exceptions. MAE would be more appropriate when variables are already expressed as percentages or ratios or net values – like the inflation rate, unemployment rate, labor force participation rate, or the current account balance. In general, the major macroeconomic variables in the real and price sectors can be predicted within reasonable error margins.

Table 2. Error Statistics: Static Simulation, 1990-2001[1]

	MAPE	MAE
Base money	11.3	
Wage (Compensation in the non-agricultural sector)	2.6	
Private consumption	0.6	
GDP	2.6	
Total investment	3.1	
Imports	10.3	
$M3$	8.6	
Exports	5.3	
Percent change in GDP implicit price index		1.6
91-day T-bill		1.5
Inflation rate		.4
Unemployment rate		0.9

[1] with the balance of payments sector exogenized.

As a first exercise, the implied dynamics of the model were assessed by noting the response of key variables to once-and-for-all-time one-percentage point shock in the BSP's policy interest rate. For this exercise, a dynamic simulation of the model (excluding the balance of payments equation) was utilized. As shown in the graph above, the responses are generally in accord with theoretical expectations. Thus, the policy shock reduces $M3$ by about 0.5 percent relative to baseline in the current year in which the policy change occurs, which then cumulates to a reduction of about 1.18 percent at the end of the simulation period. The T-bill rate, on the other hand, rises by about 0.36 percentage point above the baseline value. The

inflation rate is reduced by about 0.11 percentage point in the first year and by about 0.13 percentage point in the second year after the policy rate increase. This causes the real rate of interest to rise, which reduces investment by about 0.11 percent beginning in the first year after the policy shock. In turn, GDP growth declines by a comparatively minimal amount, which is limited to the first two years after the policy tightening. It may be noted that the simulated inflation response from the model peaks at about the second year, which lends support to the notion that monetary policy be forward-looking with at least a two-year policy horizon.

As a further illustration of the uses to which the model can be applied, consider what the model implies about a sustained one percent reduction in the volume of world trade. As shown in the figure below, the simulated export path is quite elastic, with exports falling by about 1.07 percent relative to the baseline, and GDP falling by about 0.16 percent. The peak contraction in investment happens in the second year, at about 0.25 percent. As the economy contracts, there is an initial small rise in inflation, but this rapidly disappears beginning in the second year. The initial inflation rise can be attributed to the pricing behavior in the model, which is based on unit input costs. As input adjustment lags behind output, unit costs initially rise, leading to an initial inflationary impact. Weak demand conditions result in lower-than-baseline inflation starting in the third year of world trade weakness.
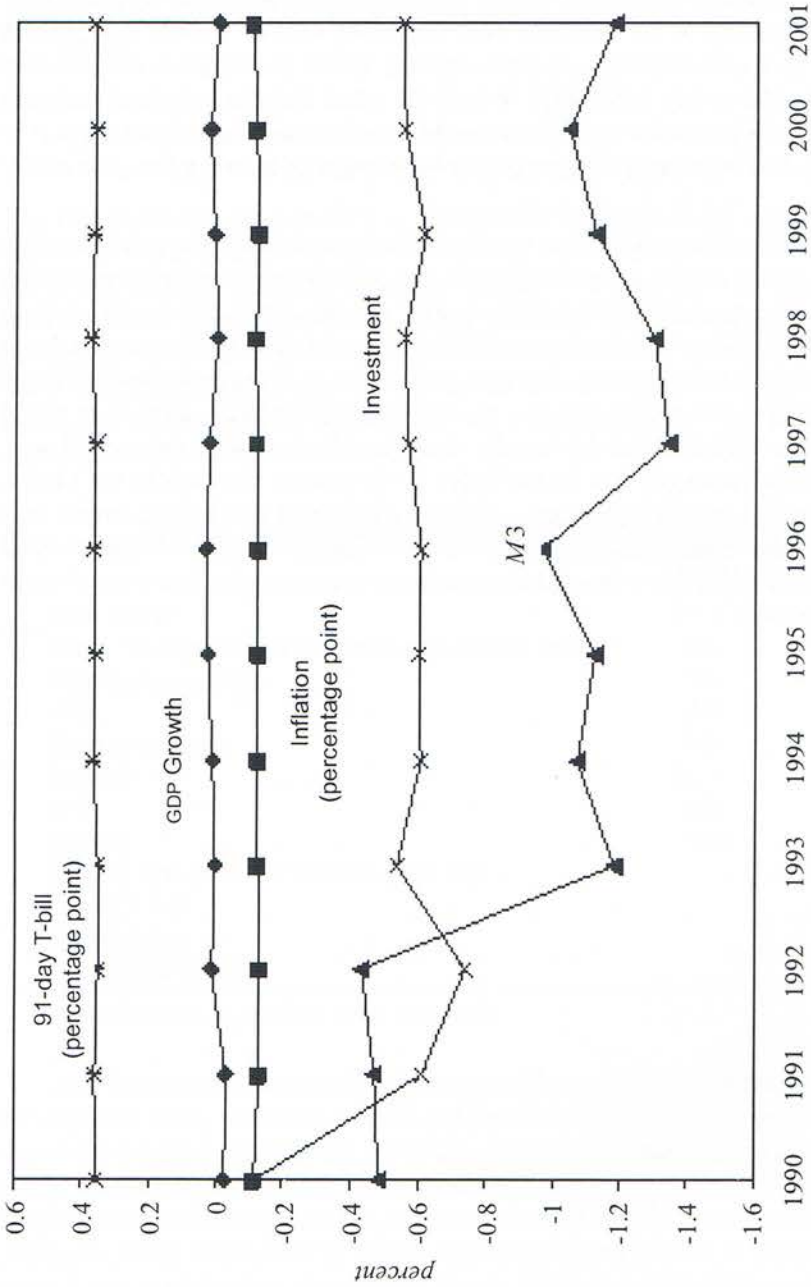
Figure 1: Impact Relative to the Baseline of Sustained One Percentage Point Increase in the RRP Rate
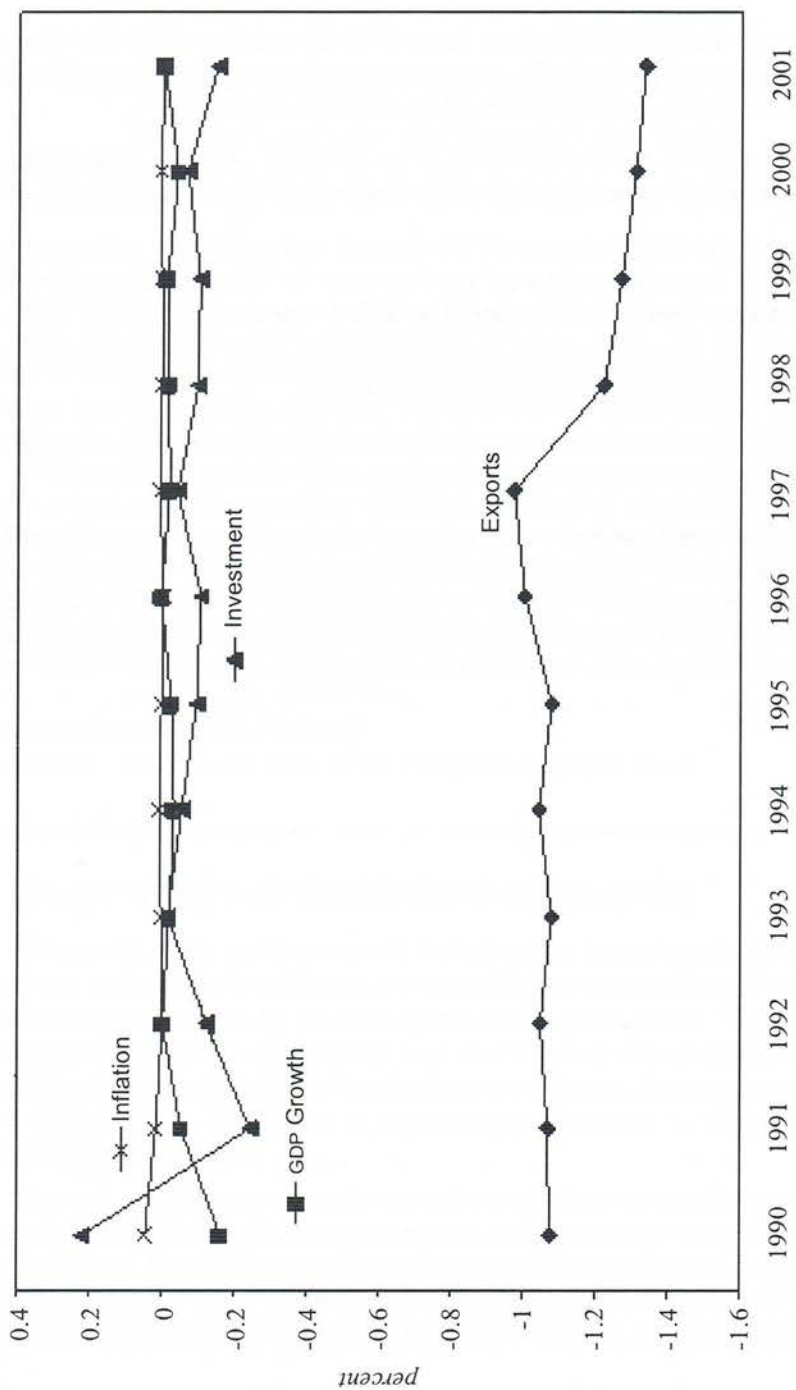
Figure 2: Impact Relative to the Baseline of a One Percentage Point Reduction in the Volume of World Trade

4. Conclusions

This paper has outlined the main features of the structure of the BSP's Long-Term Macroeconomic Model. The LTMM has several new features that build upon the characteristics of existing models of the Philippine economy:

- There is a more detailed treatment of the monetary sector and the channels through which monetary policy actions exert their impact on the economy.

- There is a careful treatment of both demand and supply side influences on inflation. In particular, the supply-side structure is rich enough to incorporate key relationships in the labor and production sectors.

- The model provides policy authorities an additional gauge on the likely directions of both core and headline inflation.

- As illustrated in the preceding examples, the model is flexible enough to handle different possible policy scenarios.

In conjunction with the other macroeconometric models of the BSP and other risk-management tools being developed, including the business expectations survey, an early warning system for the economy and enhanced collection and monitoring of key data, the LTMM can serve as a powerful component of the technical capacity necessary for success in the BSP's inflation targeting framework.