Occasional Papers No 40

INFLATION FORECASTING IN BANK INDONESIA

Halim Alamsyah

The South East Asian Central Banks
Research and Training Centre
(The SEACEN Centre)
Kuala Lumpur Malaysia

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By
Halim Alamsyah

SEACEN Workshop on Techniques of Inflation Projection
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PREFACE

As maintaining price stability is the primary objective of central bank, the ability to forecast inflation is crucial to monetary policy formulation, particularly for countries that adopt inflation targeting. While steady progress in econometric techniques and computing technology has greatly eased the tasks of inflation forecasters, changes in economic structure and higher degree of economic and financial openness, among others, have brought many complications to the tasks. Important issues such as role of inflation expectation, exchange rate and structural changes have to be considered in modeling and evaluating the forecast outputs.

The **Occasional Paper No. 40 on Inflation Forecasting in Bank Indonesia** illustrates how some of the issues above are handled in Bank Indonesia. It offers a comprehensive account of how inflation is forecast using macroeconomic models as well as other supplementary techniques such as leading indicators. It was presented as a case study at the **SEACEN Workshop on Techniques of Inflation Projection**, held in Seoul Korea, during 18-20 March 2003.

The SEACEN Centre wishes to thank Mr. Halim Alamsyah, Director of Economic Research and Monetary Policy, Bank Indonesia, for authoring and presenting this paper at the Workshop. It is hoped that the paper will provide useful information and guidance on how to handle inflation forecasting in emerging economies. The SEACEN Centre is also grateful to Bank Indonesia for making available the service of Mr. Alamsyah as speaker at the Workshop.

Views and comments expressed in the paper are those of the author, and not necessarily representing Bank Indonesia or the SEACEN Centre.

Dr.Subarjo Joyosumarto
Executive Director

The SEACEN Centre
October 2004

ABSTRACT

Since the enactment of the New Central Bank Act in 1999, Bank Indonesia is mandated to pursue a single objective of achieving and maintaining the stability of the rupiah value, primarily meant as low and stable inflation in the environment of a flexible exchange rate system. Such mandate calls for enhancement of capacity and ability to forecast inflation in Bank Indonesia.

The paper explains how Bank Indonesia forecasts inflation. It also reviews various techniques and pertinent issues in forecasting inflation, ranging from statistical methods, time series, econometric models and leading indicators. Notwithstanding the advanced econometric techniques aided by super computer, the paper reiterates that judgment continues to play an important role in forecasting inflation.

Inflation Forecasting in Bank Indonesia

By: Halim Alamsyah[1]
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I. Introduction

The enactment of the new Central Bank Act in 1999 has provided Bank Indonesia as the central bank to pursue the sole objective of achieving and maintaining the stability of rupiah value. Although the terms "the stability of rupiah" could also mean a stable and low inflation rate and/or a stable exchange rate, the single objective has been primarily meant to be on the achievement of low and stable inflation target in the environment of a flexible exchange rate system. At the operational level, at its own discretion, Bank Indonesia does occasionally intervene in the foreign exchange market with a view to reducing the volatility of the exchange rate in order to minimise the pass through effect on inflation.

In achieving the inflation target as the ultimate objective, Bank Indonesia has been granted independence in choosing the appropriate instrument in implementing its monetary policy (instrument independence).[2] Any decisions on monetary policy rest solely on the Board of Governors of the Bank, without any intervention from the Government or other parties. The new paradigm therefore calls for an accountable and transparent way of conducting monetary policy in order to have a credible monetary policy.

Along with the granted independence, the new Act however requires Bank Indonesia to announce the inflation target to the public at the beginning of every year, to report its conduct in the implementation of monetary policy every quarter, as well as to be accountable for

1. The author would like to thank Mr.Fadjar Majardi and Mr. Akhir Hutabarat for their helpful assistance in preparing the paper. Any errors remain the responsibility of the author.

2. As a note, a process of amending the Act is now undergoing in which, among others, the setting of inflation target will become a more elaborate process between the consent of the Government and the opinion of Bank Indonesia.

achieving the inflation target. Indeed, the new Act contains key features of the so called "inflation targeting framework"[3].

Bank Indonesia has made a number of efforts to enhance the quality and credibility of its monetary policy before embarking on a full fledged inflation targeting framework. Since the enactment of the new Central Bank Act, Bank Indonesia has announced the inflation target as a way to convey its intention to the public that inflation is an overriding target to be achieved. Moreover, to enhance accountability and transparency with the intention of gaining more credibility, Bank Indonesia publishes an assessment of last year performance of its policies, and announces its inflation target and monetary policy stance for the coming year.

Although Bank Indonesia has not officially committed to a full-fledged inflation targeting[4], Bank Indonesia has given much consideration on the conditional inflation forecast in its monetary policy conduct. The current practice of monetary policy is still a monetary programming aimed at achieving a certain level of base money target that consistent with the inflation target. Unlike the common practice in most inflation targeting countries, Bank Indonesia is yet to employ a policy reaction function. However, the current practice has evolved gradually towards the goal of minimising the deviation of the predicted inflation from the targeted inflation rates.

Consequently, it is important to enhance the capacity and ability to make better inflation forecasts which play a significant role in the inflation targeting framework. Many approaches have been employed. The partial and simultaneous econometric models have been built to forecast inflation. Leading indicator of inflation has also been developed to determine the cycle and direction of the inflation.

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3. By definition, the inflation targeting is a framework for monetary policy characterised by the public announcement of official inflation targets over certain horizon, by using conditional forecast of inflation as intermediate target, and by high degree of accountability and transparency.

4. For a more comprehensive explanation, see Alamsyah et. al, in "Towards The Implementation of Inflation Targeting Framework- in Indonesia", Bulletin of Indonesian Economic Studies, ANU, Australia, 2001.

In general, the inflation rate in Indonesia is broadly predictable. Nevertheless, the CPI inflation in Indonesia is very much characterised by extreme changes for certain goods, usually because of supply shocks associated with weather or seasonal patterns. In addition, CPI inflation is also highly determined by the government price adjustment policy, particularly increases in fuel price, electricity tariff and transportation fare. Given the predominant influence of supply shocks and administered price shocks, Bank Indonesia has employed CPI-based core inflation in providing an appropriate reference in determining monetary policy[5]. The use of core inflation forecast as an operational target is based on the premise that core inflation provides the right signal in formulating monetary policy responses. The use of headline inflation to guide monetary policy conduct destabilise inflation itself. However, headline inflation is used as inflation measure when announced to the public, since it will be more acceptable to the public.

The outline of this paper is as follows: Section II is a brief explanation of some techniques in forecasting inflation. Section III explains some basic propeties for good forecasts. Section IV explains about Bank Indonesia in practice produces inflation forecasts by explaining various models being employed and how it is maintained. Finally Section V presents some closing remarks.

II. Inflation Forecasting Techniques

There are several forecasting methods. In general, forecasts can be obtained quantitatively through models, or qualitatively through judgment. A purely quantitative technique applies formal and mechanical procedures to time series historical data to generate quantitative results. A purely qualitative technique is one using only judgment of forecaster(s) through combining information and forecaster's experiences. Clearly, a pure judgmental approach of forecasting has major disadvantage that it relies heavily on forecaster's expertise and other expert opinions in utilising a set of information.

5. The definition of core inflation here refers to both the trimmed mean and the exclusion methods. See Fadjar Majardi (2001) for further explanation of the method and its application in Indonesia context.

Notwithstanding the flow, the role of judgment in forecasting is still important. In some situations, it is needed to compesate for the lack of relevant historical data and for current information. Sometimes, it could complement the quantitative models that are not able to capture the whole complex structure of the real economy. Moreover, judgment has served as a complement for the quantitative techniques as the latter is viewed to be the starting point in the effective forecasting process. As a final note, models don't make forecasts, people do!

1) Statistical vs Mathematical Optimising Models

In general, quantitative methods used for forecasting can be represented by pure time series, econometric, or hybrid econometric time series models. These models are normally based on a statistical approach, e.g. pure time series models are based on economic theory such as econometric models. In econometric models, the theory will serve as the guidance to check the validity of the models while the statistical method serves as the tools to check the desirability of statistical properties of models. Some times, ad hoc procedures are also applied to enhance the accuracy of the forecasting results. However, such an approach may compromise the economic contents of the results making it difficult to explain and to gain acceptance by a wider audience.

Following the advancement of modeling techniques and mathematical programming, more and more econometric models are now also being derived from dynamic optimising behavior of economic agents within a general equilibrium framework. An example of such model is the so called stochastic dynamic General Equilibrium (GE) Models. The GE models, even at its simplest form, are actually a well specified macroeconomic framework (with consumption, investment and production side) with a more rigorous and well specified microeconomic foundation. Although it is desirable to use the GE models for short term forecasting, the experience so far with GE models shows that this type of models is most suitable for medium and long term forecasting. It can also be used for some policy simulation and analysis with regard to economic implications of some particular structural changes, policy regime change or a-typical shocks.

2) Time Series vs. Econometric Models

When one is faced by the practicality of producing forecasts as accurate, timely, and reasonably accepted as possible, most will look at time series or econometric models. As a statistical based model, time series model presupposes that any piece of data can be decomposed into a time trend, a cyclical element, a seasonal factor and an error or random term. A wide variety of techniques is available to break up a time series into these components and thereby to generate a means of forecasting future behavior of the series. As an a-theoretical approach, these methods are based on the supposition that history provides some guide as to what to expect in the future. The main application of this method is the Box-Jenkins (ARIMA) approach that is normally characterised as a univariate framework. The variant of this method is a structural time series approach (or transfer function models) that combines univariate time series with structural causal model.

Econometric methods rely on statistical procedures to estimate relationships for economic models specified on the basis of theory, information from previously published studies, and domain knowledge for a specific situation obtained by interviewing experts. Given good prior knowledge about relationships and good data, this approach incorporates existing theoretical and empirical knowledge of how the economy works. The term "econometric" refers to the application of statistical regression techniques to the process of economic modeling. The purpose of the regression analysis is to estimate the values of the parameters in a model that best fits the characteristics of a phenomenon, which is the object of analysis.

Since the advancement of co-integration theory, however, "hybrid" econometric time series models have been developed. This "hybrid" models exploit the properties of long run time series behavior of many economic data embedded into particular models together with some short run behavior. For example, we can model an equation in which in the long run all prices should move in the same direction or even converge (and thus "co-integrate") while in the short run it can deviate from the long run behavior due to many short term and temporary shocks.

3) Small And Large Macroeconometric Models

In many cases, macroeconometric models are also useful in making forecasts. As the name suggests, macroeconometric models may consist of several sectors of the economy such as private, government, external, production, prices, and monetary sectors. Thus, it may involve many data and policy variables.

Consequently, macroecometric forecasting model could range in sophistication from two equations to a large system of equations that is solved simultaneously (simultaneous-equation models). Unlike in single-equation models, a number of dependent variables in simultaneous equations appear as explanatory variables in more than one equation. These dependent variables are simultaneously determined by other dependent variables and explanatory variables in the system. The number of equations included in macro econometric model determines the scale of the model.

The strength of macroeconometric models lie in its ability to produce results consistently and based on economic theory. However, its practical use will depend on the needs of forecasters. In general, small macroeconometric models tend to be used if decision making process demands a timely and accurate forecast with a reasonable theoretical ground. This could be complement by large models to confirm and improve the results.

4) Leading indicator

As a complement to macroeconometric model that provides forecast of variable's magnitude, leading indicator can also be used to predict the future direction of business cycle related variables. This approach is sometime called "signal-extracting" approach (or "measurement without theory" for the skeptics) as it is based on pure statistical approach by decomposing time series data into trend, cycle, seasonal and random components.

Thus, the first step of this signal-extracting approach is to determine which data should be used as the reference series (for example the CPI in case of building leading indicator for inflation) and the indicators. The second step is to decompose these data into the trend, cycle, seasonal and random components by various filtering techniques. The next step is to identify the cycles of the reference series by their turning points, both peaks and troughs. This cycle will thus serve as the reference for time series data which are candidates as the leading indicator. Assessing the candidates for leading indicators will require the identification of the cycle and matching its peaks and troughs with that of the reference series. The chosen leading indicators should consistently reflect a "lead" or precede at both peak and troughs of the reference series. Finally, the chosen indicators will be combined into a single synthetic index and use to predict future direction and turning points of the reference series (inflation), which can be useful in guiding the policy responses.

III. What Is A Good Forecast?

The purpose of forecast is to enable decision makers to make appropriate policy responses with a given set of information at hands. In the case of inflation forecasts, it can be a great help for policy makers as it can confirm the appropriateness of the current policy stance or alert the policy maker to take policy response should the forecast indicates that the inflation outlook may deviate from the target. Therefore, accuracy is the primary criterion of what can be considered as a good forecast besides other factor such as timeliness and theoretically explainable.

1. The Accuracy of Forecasts

Many forecasts can be derived from many techniques. However, it is well known that point forecasts made from linear regression models estimated by least squares are optimal in the sense that they have the smallest forecast variance among other forecasting method. Based on this knowledge, the desirable properties of optimal predictors are thus as follows:

1) Unbiased, Conditional on Information at t.

Forecasting error is defined as the difference between the actual and forecasted values. As long as this error approaches zero in the long run, the forecasts will an unbiased estimator of the true value of the variable in question. Assuming that the model is correctly specified[6] there are two sources of forecast error: (i) residual uncertainty and (ii) coefficient uncertainty.

(i) Residual Uncertainty

The first source of error, namely residual or innovation uncertainty, arises because the innovations in the equation are unknown for the forecast period, and are replaced with their expectations, which is equal to zero. While the residuals are zero in expected value, the individual values are non-zero. The larger the variation in the individual errors, the greater the overall error in the forecasts. The standard measure of this variation is the standard error of the regression. Residual uncertainty is usually the largest source of forecast error.

(ii) Coefficient Uncertainty

The second source of forecast error is coefficient uncertainty, meaning that the estimated coefficients of the equation deviate from the true coefficients in a random fashion. The standard error of the estimated coefficient is a measure of the precision with which the estimated coefficients measure the true coefficients. The effect of coefficient uncertainty depends upon the exogenous variables. Since the estimated coefficients are multiplied by the exogenous variables in the forecasts horizon, the more the exogenous variables deviate from

6. Specification error exists when the assumptions of classical linear regression are not satisfied, in particular that not all relevant explanatory variables are included, that the functional form is incorrect, and that there has been regime changes.

their mean values (conditioning error[7]), the greater is the forecast uncertainty.

In the absence of specification error and conditioning error, $\acute{y}_{T+h}$ is the best linear unbiased forecast since in that circumstances the estimated coefficients are the best linear unbiased estimator.

$$E(\acute{y}_{T+h}|Y_T) = E(y_{T+h}|Y_T)$$

or

$$E(y_{T+h} - \acute{y}_{T+h}|Y_T) = E(e_{T+h}|Y_T) = 0$$

where e_{T+h} is the forecast error

2) Minimising The Expected Value of a Given Loss Function

Assuming we already obtain unbiased forecasts, further criteria will be made according to the efficiency of each forecast. There are several forecast error criteria that can be used as a measure of forecasting efficiency within forecasting out-of-sample observation. The most efficient predictor is the one that minimises the chosen forecast error criterion.

(i) Root mean square error (RMSE)

This "quadratic loss function" is the square root of the average of the squared values of the forecast errors. This measure implicitly weights large forecast errors more heavily than small ones and is appropriate

7. Conditioning error exists if the value of explanatory variable in forecast horizon, X_{T+h} is inaccurate

to situations in which the cost of an error increases at the square of that error.

$$RMSE = \sqrt{1/T\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}$$

(ii) Mean absolute deviation (MAD) or mean absolute error (MAE)

This criterion is the average of the absolute values of the forecast errors. It is appropriate when the cost of forecast errors is proportional to the absolute size of the forecast error.

$$MAE = 1/T \sum_{t=1}^{T}\left|Y_t^s - Y_t^a\right|$$

(iii) Mean absolute percentage error (MAPE).

This is the average of the absolute values of the percentage errors. It is more appropriate when the cost of the forecast error is more closely related to the percentage error than to the numerical size of the error.

$$MAPE = 1/T \sum_{t=1}^{T}\left|\frac{Y_t^s - Y_t^a}{Y_t^a}\right|$$

3) Conditionally Efficient

A forecast A is said to be conditionally efficient relative to forecast B if B possesses no useful information beyond that contained in A. One way of determining this is to combine A and B into best combination forecast and see if the variance of the resulting forecast error is significantly smaller than that resulting from forecasting with A alone. The variance of unbiased predictor is the expected value of squared forecast error.

$$V(e_{T+h}|I_T) = E(e^2_{T+h}|I_T) - (E(e_{T+h}|I_T))^2 = E(e^2_{T+h}|I_T)$$

All the above properties are required for a given forecast to be reasonably accurate and more reliable than the alternative ones. This objective requires the forecasting model to have the following properties (Clements and Hendry, 1998):

It is well specified, so that the model fully embodies the available data information;

It dominates alternatives, which is its encompassing ability, namely how well it accounts for the results obtained by rival explanations;

It remains stable even if there are regime shifts or structural change; and

Parameters are accurately and precisely estimated, to minimise the impact of estimation uncertainty.

2. Simplicity, Timeliness and Flexibility

Despite the fact that generating an accurate forecast is a supreme objective in a forecasting process, there are other factors should also be taken into account. The forecasting model should also be explainable to the policy maker, both in economic theory and in practical sense. The simpler the model, the better it is in terms of gaining acceptance by policy makers who make decisions. Accordingly, there must be a balance between utilising a sophisticated forecasting approach that provides more accurate estimations and utilising a simple approach that provides more understanding and acceptance by policy makers.

Simplicity of a forecasting model is related to ease of producing forecast and the timelines that forecast could be made available to the policy maker. The forecasting model involving complex structure of system and complicated mathematical process might face problems concerning data availability, as well as a time consuming forecasting process. This leads to the trade-off of between large-scale macro models and the smaller ones.

Besides those two problems, the other issue related to forecasting process is flexibility. The process of forecasting needs flexibility in combining arts and science into yield a better result. We know that the building of models is based on science or clear theoretical background and they are very useful in making an accurate and explainable forecast. However, models are only tools that used by the people to make a forecast. They can never produce better and accurate results unless they are handled with care by the people behind them. Therefore, the result depends on the people doing forecasting task. Not only science and theory that are required by the modelers to make and run the reliable model, but they also need intuition as the art of modeling.

IV. Forecasting in Bank Indonesia

1. Model Building and Development

Since 1987 Bank Indonesia has devoted concerted efforts in building and developing annual macroeconomic and sectoral models for short terms forecasting and policy simulation. As Bank Indonesia's needs for quantitative analysis was growing, divisions were set up in the economic research department in early 1990s to handle modeling and forecasting. The experience so far suggests that quantitative analysis has been very useful in enhancing the transparency and accountability of the decision-making process in Bank Indonesia while adding perspectives and more knowledge on many important aspects of the working mechanism of Indonesian economy.

When the financial crisis hit the Indonesian economy in 1997, the needs to have quick yet well grounded economic analysis were growing. This led to the building and developing of smaller economic model, both macro and partial models. Two kinds of macro econometric model had been developed since then. The first one is called SSM (a quarterly small scale macro model) and the other one is called SOFIE (a quarterly medium scale macro model). However, to enhance the medium and long term policy analysis, Bank Indonesia also developed a dynamic macro model using the general equilibrium approach, the so called

GEMBI. In addition, a number of partial models had also been developed to support the accuracy of forecast output from macro model.

The development of these models is supported by the development of staff capability and the availability of quantitative software packages. Unfortunately, different quantitative software are used in estimating or solving different models. While the pioneer model (MODBI) uses SIMPC, a software developed by an expert from Central Planning Bureau of the Netherland, the other small macro models such as SSM and SOFIE are using E-views. In a later development, the extended version of SSM (SSM-X), which accommodates forward expectation, requires the solving of expectation variables endogenously. Consequently, the SSM-X model uses TROLL software. Furthermore, the general equilibrium model (GEMBI) is supported by the uses of Mathlab software. However, user friendly E-views continues to be the most used software in many other partial models.

1) Macro Economic Model of Bank Indonesia (MODBI)

MODBI is a short and medium term macro model that serves as a tool to make projections and simulations to asses the impact of changes in economic conditions or policies. MODBI essentially distinguishes two markets: the goods market and the financial/monetary market. The less reliable labour data prohibits the construction of third market, namely the labor market. The description of goods market contains Neoclassical as well as Keynesian elements. Potential supply is determined by accumulated past investments. Total demand is calculated by adding up private, public and foreign expenditures and subtracting the demand for import. In the short run, production is demand determined. Disequilibrium between demand and supply, measured by the utilisation rate of capital stock, will lead to reactions in prices and investment rate, both in a direction to bring demand and supply more in line with each other. Therefore in the medium term, supply factors will determine the production level.

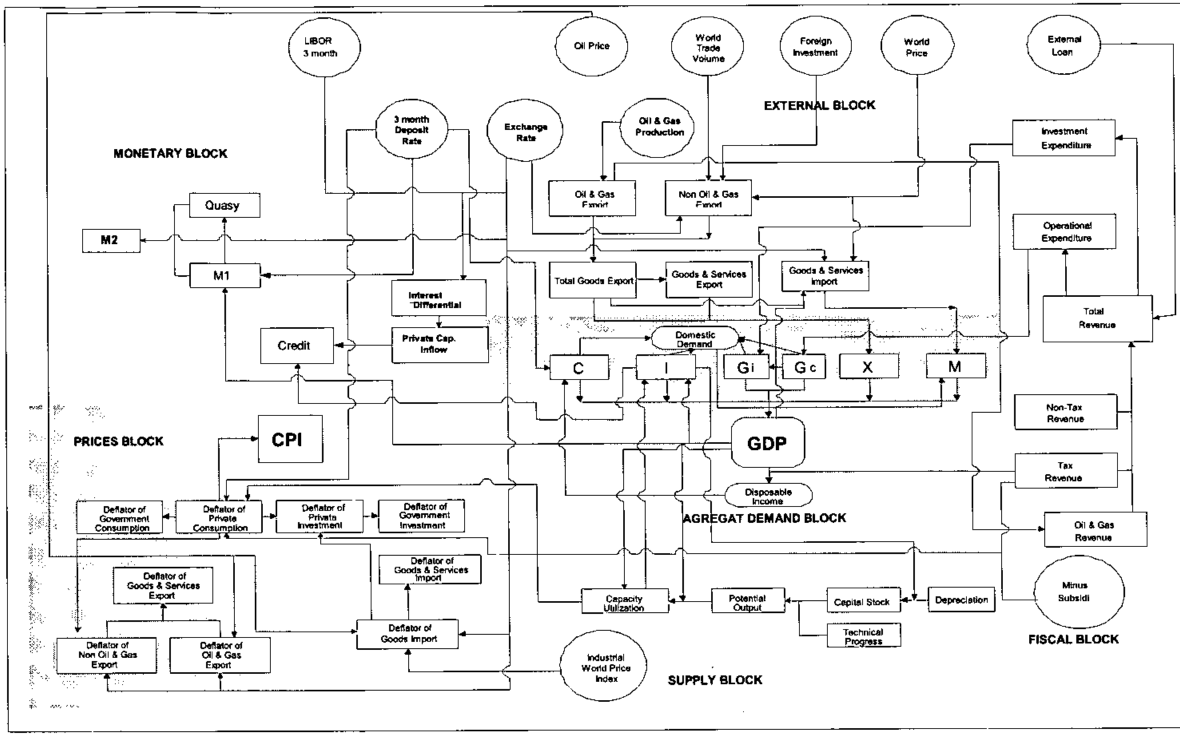

Diagram 1: Schema of MODBI Transmission

The monetary block contains five financial sectors, namely the monetary authority, commercial banks, private, government, and rest of the world sectors. A flow of funds accounting system describes their interrelations. It is closed by having saving account in surplus or deficit in each of the private, public, and external (current account balance) sectors. Domestic interest rate is assumed to bring the equilibrium in the market for saving and demand deposit while the exchange rate is following a Purchasing Power Parity (PPP) type of equation as a reflection of a small open economy. MODBI also contains an extensive description of the government budget and a separate block for dividing total output or GDP into sectoral production.

The MODBI model uses annual data, consisting of 178 equations with 315 variables. About 38 equations are behavioral while the rest are the so called definitional equations or economic identities. Ordinary least squares technique is used in general. In some cases, the more elaborate co-integration technique is used.

2) Small Scale Macro Model (SSM)

Since 1999 Bank Indonesia has developed a quarterly small macro model in order to get a quicker and yet well economic grounded quarterly inflation forecast. The model uses the Phillips Curve approach as the key equation in explaining the dynamic of inflationary pressure. The first version of SSM consists of eight behavioral equations. However, after some experimentation and known weaknesses particularly in explaining the dynamic of demand-side inflationary pressures, this leads to an improvement of SSM into an extended version (SSM-X). SSM-X includes 16 behavioral equations, doubled the number of behavioral equations in the original version. Those equations are divided into three blocks: (i) monetary block, (ii) real sector block, and (iii) prices block.

SSM-X has been able to provide a better inflation analysis as: (i) it embodies forward-looking inflation expectation that is endogenously determined within the model, (ii) it identifies demand pressures inflation as a consumption driven phenomenon in Indonesia, and (iii) it uses a core inflation equation as an important indicator in guiding and formulating

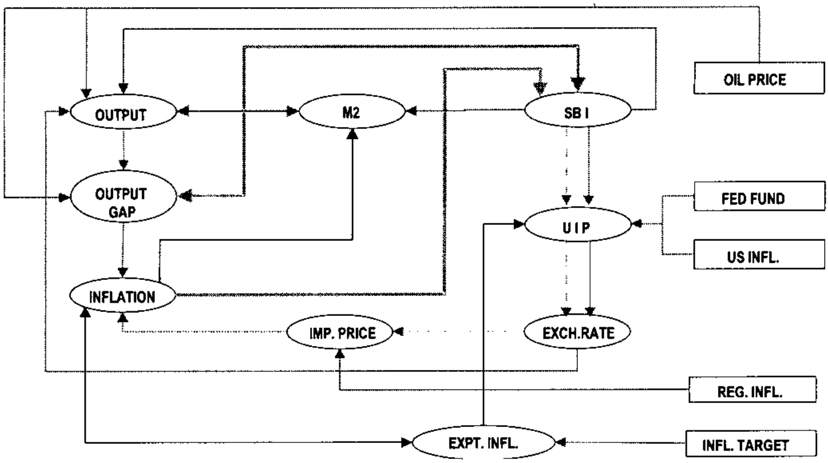

Diagram 2: Structure of SSM

monetary policy. Unfortunately, these extensions in turn demand a more detail and complex equations. For examples, the use of consumption variable necessitates the use of a more disaggregated output equation into its expenditure variables; the use of core inflation variable in the model needs an additional equation to explain the movement of CPI inflation. In addition, a term structure and money demand equations have been used to have better linkages with the monetary sector. However, the exchange rate is still exogenous in this model.

Limited information on output gap as an important source of demand pressures of inflation has forced the modeler to find a substitute indicator. To identify the demand pressures of inflation, SSM-X makes use of a "consumption gap" (the difference between desired/potential and actual consumption). This consumption gap variable is in line with CPI inflation, which is constructed from prices of goods and services that are most likely consumed by households.

In the former model (SSM model), forward expectation of inflation were determined by synchronising consensus forecasts from various institutions and BI's inflation target, which is solved exogenously. This approach made SSM model very sensitive to forecaster's judgment. In order to minimise forecasters' judgment, in the later model (SSM-X), forward expectation of inflation is estimated endogenously. This is done by using TROLL software as it has the property to solve the lead variable endogenously by using Fair Taylor method or Stacked Newton method.

In the model, core inflation is used as the key variable of inflation in the Phillips Curve equation, since core inflation is better in explaining the persistence and general movement of general prices. Consequently, core inflation is also employed in the so called Taylor type rule to guide the monetary policy responses. The definition of core inflation being used here is based on the exclusion method, which tries to eliminate the most volatile components and price policies from the headline CPI, i.e., food and administered price adjustments.

However, since the headline CPI inflation is the official target, efforts are also being made to forecast volatile food inflation and administered price inflation. Thus, the forecasted headline of CPI inflation will be a weighted average of core, volatile food and administered price inflations. In total, SSM-X has 4 additional prices equations, namely: (i) equation of core inflation, (ii) equation of administered price inflation, (iii) equation of volatile food inflation, and (iv) equation of CPI inflation.

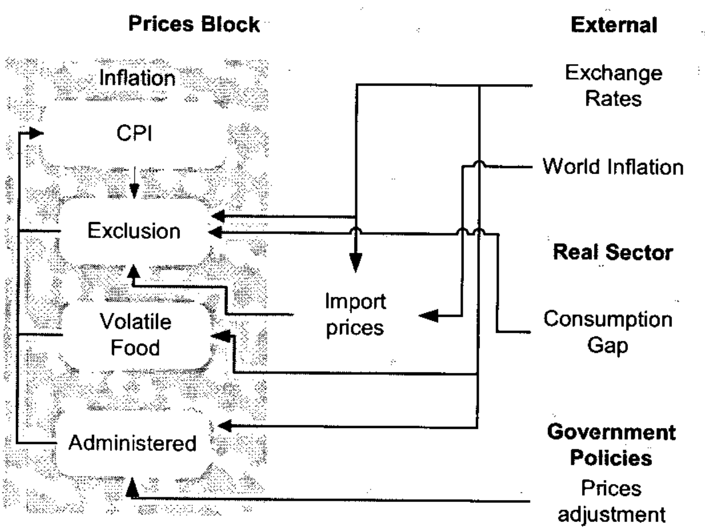

Diagram 3: Structure Model SSM-X Prices Block

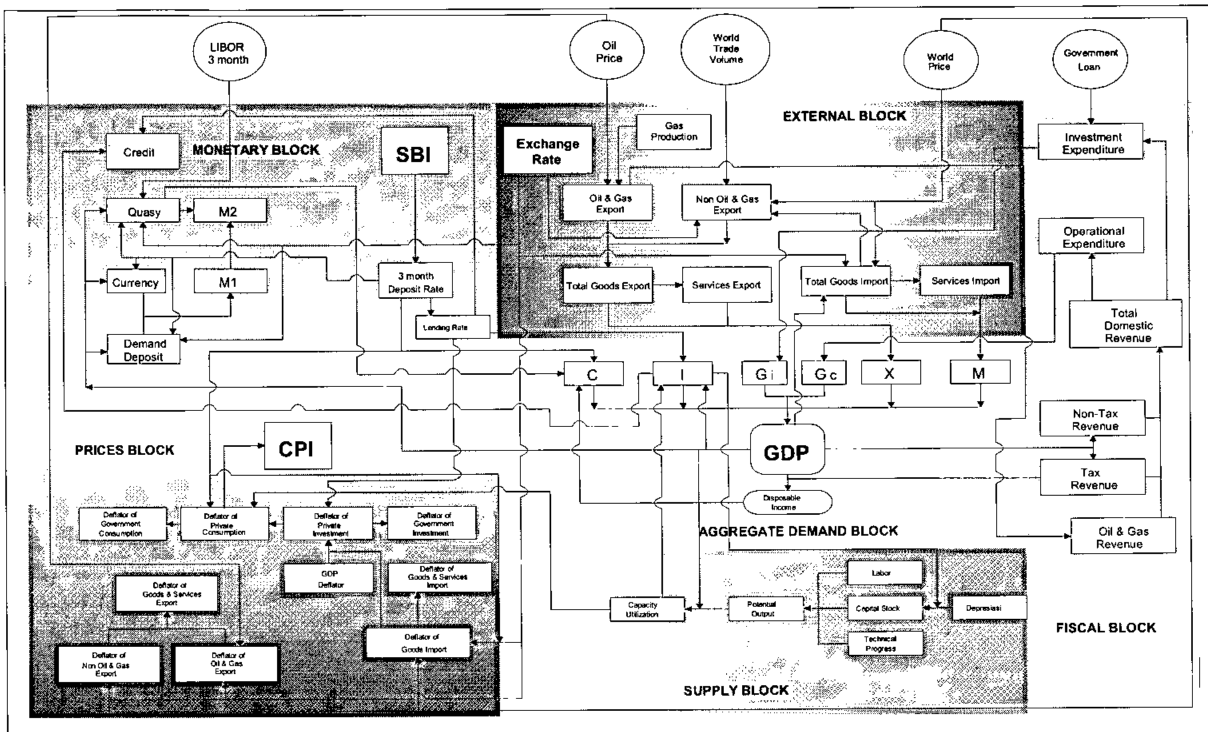

Diagram 4: Structure of SOFIE

3) Short Term Forecast Model of Indonesian Economy (SOFIE)

As MODBI is an annual model, the need to have a better knowledge on the developments of business cycle in the economy is clearly there. In this purpose, SOFIE is built to help analyst to gain better understanding about the dynamics of the economy and at the same time is designed to help the analysis and forecast of inflations. SOFIE is thus a quarterly macro economic model and like MODBI it distinguishes two markets: the goods market and the monetary market. No attempt to put labor market in the model as the data problems do not permit it.

The basic theory used in this model is a combination between Classical and Keynesian. Specifically, it contains three main elements, that is: Classical aggregate supply theory, Keynesian aggregate demand theory, and price adjustment theory when there is a gap between demand and supply. This model assumes that in the long term there will be equilibrium between aggregate supply and aggregate demand, but if there is disequilibrian in the short term, it will be captured in the economic capacity utilisation that eventually exerts price pressures in the economy. Furthermore, the adjustment in output and prices will occur through dynamic processes.

The main differences between SOFIE and MODBI are that SOFIE uses quarterly data and its number of equations is not as many as that of MODBI. SOFIE model only consists of 36 behavioral equations and 23 identity equations. Half of behavioral equations are estimated by the error correction model (ECM) approach to capture the linkage between long term and short-term equilibrium.

4) General Equilibrium Model of Bank Indonesia (GEMBI)

As both MODBI and SOFIE are in principle short term models, the need to have a model that can handle longer term analysis and policy simulations is growing. Furthermore, rapid changes and structural adjustments occurred in the Indonesian economy in the aftermath of 1997 financial crisis, might change the behavior as well the functioning of the economy as business, consumers and government adapt their behavior. Given such an environment, shocks that create structural changes might be problematic for MODBI and SOFIE models which are in principle based on historical behaviors. With this motivation, the problem at hands can best be tackled through developing a model that has a long term or steady state properties, incorporates forward looking and rational expectations, and based on optimising behavior of economic agents in the economy.

Thus, since 2000, Bank Indonesia has embarked on building the so called GEMBI[8] that uses the general equilibrium approach. During the last two years, GEMBI has been developed from a relatively simple model to a more complicated one. There are five sectors in the model: households, banks, traded and non-traded firms, external, and government sectors. All agents except government have their own objective functions and budget constraints. The optimisation behavior of each economic agent will dictate the role of each agent in the model. The interaction of the agents is represented by 26 equations in the model, about half of them are behavioral equations derived directly from the optimisation solution in each sector.

8. GEMBI is a stochastic non-linear dynamic general equilibrium (SNDGE) model. The construction of the model started in June 2000, developed by a team of Bank Indonesia economists at the Macroeconomic Studies Division of the Research and Monetary Policy Directorate (DKM/SEM) of Bank Indonesia. The model evolved from a theoretical concept to an operational policy instrument, for ongoing analysis and evaluation, with the assistance and advice of Prof Paul D McNelis under the Partnership for Economic Growth (PEG) project of the U. S. Agency for International Development (USAID).

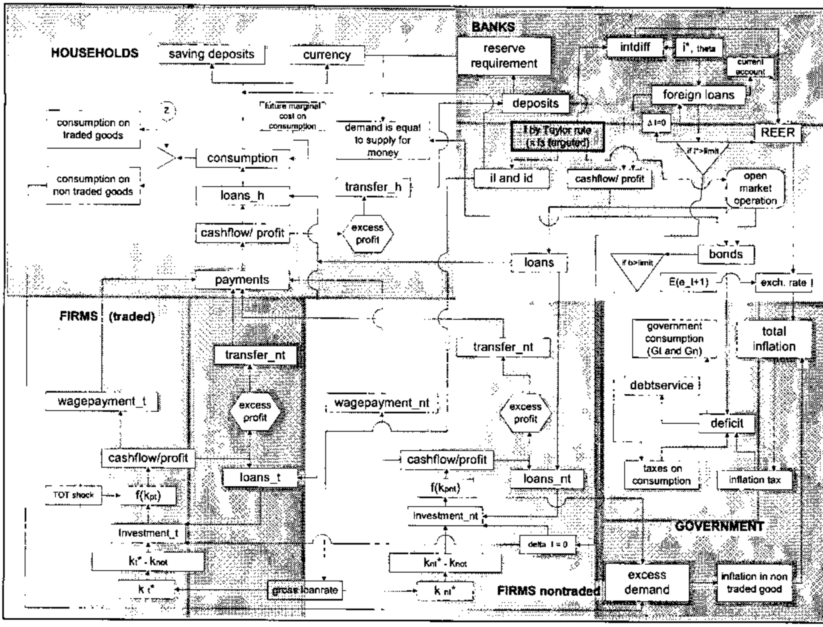

Diagram 5: Scheme of GEMBI Transmission

It is quite clear that the strengths of GEMBI lies in its well founded economic theory with optimising behavior of agents embedded in the model. Economic analysis and policy simulations are thus free of the "Lucas critique". However, as a stochastic non-linear dynamic general equilibrium (SNDGE) model, GEMBI has a complex model structure which creates challenges in finding the true parameters of each equation. In addition, the higher demand for data and information which may force the analyst to resort to use instrumental variables.

5) Partial Models

Besides macro models, BI also developed partial models to support the outcomes of those macro models. There are a numbers of partial models that had been developed at Bank Indonesia. However, in this paper only two partial models will be explained for their important contribution in the process of inflation forecasting.

(i) Behavioural Equilibrium Exchange Rate (BEER) model

BEER is used to forecast the exchange rate. BEER model gives a more accurate short term exchange rate forecast as compare with that of macro models. BEER is estimated by using the error correction models to capture the linkage between long term and short-term behavior. The dependent variable used by this model is REER (real effective exchange rate), which is a function of risk premium, productivity of traded sector, terms of trade, net foreign assets, and interest rate differential. The result of this model is called "fair" value. In practice however, the fair value is combined with the "market" value, which is extracted from the survey and the consensus forecast, to finally come up with the realistic forecast of the exchange rate.

(ii) GDP forecast by sector

The model is basically forecasting the GDP based on the production approach. This model is used to evaluate the consistency of the GDP forecast that comes from the macro model (expenditure approach). Furthermore, this model can provide information such as what sector constitutes the backbone of the growth, how strong are the growth of some important sector based on information gathered by the sectoral analyst, etc. The model tries to forecast the development of nine sectors, which eventually will be combined into total output from the production side.

6) Indicator model

Indicator model has the function to complement with macro model and partial model, which produce projection of economic indicator magnitude. Indicator model is used for predicting the direction of one variable by identifying its movement cycle based on the turning points, namely peaks and through. The existing indicator models are Inflation Leading Indicator, Economic Growth Leading Indicator, Leading Indicator for Banking Crisis, and Exchange Rate Technical Analysis Model.

(i) Inflation Leading Indicator (LII)

In an attempt to increase the effectiveness of monetary policy, the monetary authority has to know in advance future inflation development. However, inflation development is one of the indicators, which are difficult to predict accurately. Inflation Leading Indicator is prepared as one of alternative reference for estimating future inflation rate directions. Inflation Leading Indicator is composite cyclical indicator, which shows the direction of future inflation rate development. Inflation Leading Indicator is established using non-parametric cyclical method and does not estimate aggregate inflation. Based on the Inflation Leading Indicator (LII) developments, the turning point can be identified, peak as well as through, thus the directions of future inflation development can be known. Inflation Leading Indicator is established by determining inflation cycle as a series of reference, and is continued with the establishment of composite index Inflation Leading Indicator. The items in Inflation Leading Indicator that must be paid attention are M2 real, composite index, total credit, SBI, total clearing notes, and WPI import. The resulted output is information/signal of inflation direction and turning point, which is a guidance for monetary policy determination.

(ii) Economic Growth Leading Indicator

Basically, this model is similar to Inflation Leading Indicator. The method for establishment and measurement is also similar to that of Inflation Leading Indicator. The purpose of Economic Growth Leading Indicator is to provide information or signal/direction of economic growth movements. Items to be paid attention in economic growth leading indicator are M2 real, composite index (IHSG), CPI, clearing volume, business survey (SKDU). The measurement method is similar to that of inflation leading indicator, and the resulted output is information/signal of direction and turning point of inflation, which is a guidance for monetary policy determination.

(iii) Exchange Rate Technical Analysis Model

Exchange rate expectation with the use of fundamental factor only is less able to explain exchange rate, in other words, exchange rate movement in short-term most oftenly cannot show relationship with fundamental factor. It can happen because in short-term market expectation of future exchange rate development direction is established on basis of extrapolation expectation. Thus, in short-term the relationship between exchange rate and economic fundamental factor can be distorted by market player' action to extrapolate price development or to follow a strategy that is largely based on trend analysis

Technical analysis is a study on "market action", particularly with the use of graph for the purpose of making future forecast. The terminology of market action covers three important information, namely price, volume and open interest. Out of these data, other indicators are developed, among others: moving average, Bollinger Band, Oscilators, Momentum, Relative Strength Index, Support Resistance, and the like. These indicators are used to evaluate BEER output.

2. Interconnection of Models: The Forecasting System

Various models that had been explained earlier have been used for forecasting. This is motivated by the facts that different models obviously will have different forecasts results with different forecasting power due to their different characteristics and assumptions. Using different models is advisable since they could complement to one another, leading toward a forecasting system suit of different models. A good example in this respect is the used by the Reserve Bank of New Zealand (RBNZ) and Bank of Canada Forecasting and Policy System (FPS).

To date, Bank Indonesia has not yet had a system to link those models in practice. The study of how interconnected these models are to one another is still in progress. A study is underway as to whether Bank Indonesia should use the general equilibrium model or GEMBI as a core model (like FPS in New Zealand). Alternatively, whether SOFIE or SSM-X should be used as the core models as in the Bank of England that uses a macroeconometric model. Another alternative is not to use any particular model as a core model. Decision on this is still pending as models are still being refined and under development.

1) Existing Forecasting System

In the mean time however, Bank Indonesia uses all the models to produce forecasts and during this process some coordination and fine tuning naturally takes place. Before 1999, MODBI was the only macro model Bank Indonesia used to make forecasts. Since 1999, however, several models had been developed, prompting questions of which models should be used as the core and which as the satellites. Presently, all models are used in the process of producing the forecast, and no model is assumed to be superior than others. This is what called a "joint model" approach. The system works more or less in a recursive process, where the output of one model is used as an input variable for the other model.

Choosing which model to be input or output model depends on the confidence over the structure and the performance of the model. The models that can theoretically and clearly explain the source of forecast movements should be chosen as an output model. Looking from the perspective of inflation forecasting, this starts from the decision on which model has the ability to clearly explain the source of inflation pressure. Furthermore, to increase the unbiasedness and efficiency, results from one model can also be used as inputs in to other models. Alternatively, we can also use some form of weighted average of different forecasts together. To decide what weights to be assigned to a certain model will of course depend on its performance with regard to the ability to predict the actual inflation closely. Models that can track the actual inflation

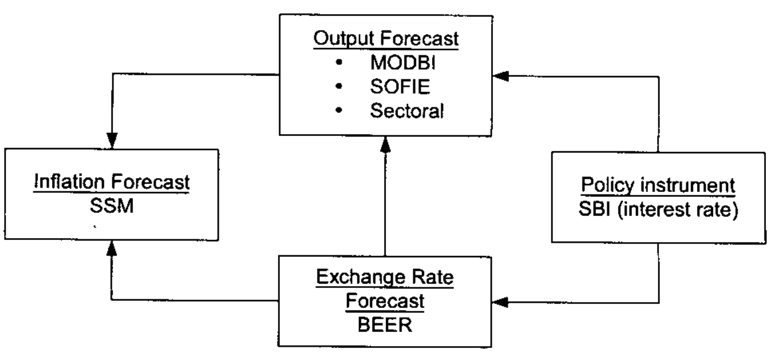

Diagram 6: Inflation Forecast System
(The Link among BI's Models)

consistently better than others naturally will be given higher weights. In some cases, statistical properties of models such the calculated Akaike Information Criterion can also be used to form a system of forecasting.

(i) Inflation Forecast Model

Amongst inflation model, SSM is considered as the most able one in explaining the source of inflation pressure. This model utilises the augmented Phillips Curve, combined with seasonal pattern and some additional shocks. The shocks mostly come from the government price policy. SSM gives a clear information about the source of inflation pressure whether it comes from expectation (π^e_{bw}, π^e_{fw}), demand pressure (output gap: Y-Y*), external impact (e), seasonal movement (sf), or government shock.

$$\pi = \alpha_1 \pi^e_{bw} + (1 - \alpha_1) \pi^e_{fw} + \alpha_2 (Y - Y^*) + \alpha_2 e + \alpha_4 sf + \text{shocks}$$

However, SSM needs assistance from the other model to increase the accuracy of the forecast. The GDP and exchange rate forecast from SSM are quite weak because they are estimated from a simple model[9], where the forecast output is less explainable and has a low accuracy.

(ii) GDP Forecast Model

A better GDP forecast is resulted from large macro model that can clearly explain the source of GDP growth in much more detail. In practice, the GDP forecast is obtained from a combination of MODBI and SOFIE. While MODBI gives an annual forecast, SOFIE adjusts its results and gives a quarterly path of GDP forecast. Furthermore, this number is also crosschecked by the results from the GDP sectoral model. However, as also experienced by SSM model, these macro models still need supports from specific model such as BEER to get a more accurate exchange rate forecast.

9. See appendices

$$Y = C + I + G + (X - M) = \sum_{i=1}^{9} Y_i$$

i= sector in GDP

(iii) Exchange Rate Forecast Model

Besides inflation and GDP, exchange rate is another main economic variable that that plays a very important role in forecasting other economic variables in Indonesia. In order to get a more accurate exchange rate forecast, Bank Indonesia uses BEER model as a main model in forecasting the short-term exchange rate movement. Almost all models in BI use the outcome from this model as the expected exchange rate movement. The BEER model is as follow:

$$\Delta REER = \alpha_0 RP + \alpha_1 \Delta TNT + \alpha_2 \Delta TOT + \alpha_3 \Delta NFA + \alpha_4 \Delta FDI + \alpha_5 \Delta RID + \alpha_6 ECM(-1)$$
$$ECM = REER - (\alpha_0 + \alpha_1 TNT + \alpha_2 TOT + \alpha_3 NFA + \alpha_4 FDI + \alpha_5 RID)$$

Where:

REER	=	Real Effective Exchange Rate
RP	=	Risk Premium
TNT	=	Tradable and Non-tradable
NFA	=	Net Foreign Assets
FDI	=	inflow of Foreign Direct Investment
RID	=	Real Interest Rate Differential

As mentioned earlier, the result from this model is called the "fair" value. The "fair" value is then averaged with "market" values that are obtained from survey and consensus forecasts made by other forecasting institutions.

As a final note, initially some of the above models are built as tools for making better inflation forecasts and facilitating some policy analysis and simulation. In latter stages however, by designed, the system has been focused on making a more accurate inflation forecasts since some main economic indicators in BEER and SOFIE, for example, are not solved endogenously which may be inconsistent if one tries to do some policy simulation. However, the progress being made in GEMBI should enable us to providė some long term policy analysis consistently since GEMBI has all the properties required in such an analysis i.e. optimising behavior of economic agents leading toward a particular steady state condition, rational, and free of "Lucas critique". Thus, in practice, we use GEMBI and Indicator Models to check the general direction of the state of the economy for long-term forecast (beyond one year forecast periods).

2) Design of Future Forecasting System

As mentioned before, the study of how to interconnect the models is still in progress. However, preliminary result of this study shows a strong tendency that the system will adopt model architecture of Bank of England, which uses a single core model based on macroeconometric model (MM). Main consideration factors underlying the system preference are accuracy, transparency, explainability, practicability, and existing technical competency. However, the other important properties of core model, which are theoretical coherence and ability to represent essential transmission mechanism, are also put into consideration. In this respect, the core models currently available at Bank Indonesia are reviewed to identify the degree of their similarity to the characteristics and approaches available at BOE, and the process required for building model architecture.

From the *benchmarking,* it is obvious that there is no one model that can meet all the MM criterion of BOE. Thus, following alternatives can be attempted: (1)To build a complete new model in accordance with the MM characteristics, or (2) to improve one of the currently available macroeconomic models to be closer to the MM model characteristics.

Of the above models, SSM-X and SOFIE can be in synergy to get closer to the characteristics of MM model, because both models have similarities in (1) model structure and policy transmission mechanism, (2) model estimation method and (3) data estimation period. However, each model carries weaknesses when it is used for policy analysis as well as macroeconomic variable projection. As known, SOFIE is built on basis of theory and "long run equilibrium" pattern more consistent with MM (for example money and inflation neutrality, equilibrium condition in export and import equation, and the like). On the other hand, the SSM-X is not in operation yet, however result of the "in sample forecast" shows more accurate projection relative to the SOFIE model.

Thus, the strategy to build core model is heavily dependent on the choice of model designated as the basic framework of its development. In case the SOFIE model will be used for the basic framework, the accuracy of the projection must be improved with the insertion of short-term equation available in the SSM-X model. Meanwhile, when the SSM-X model is selected, the long-term equation in SOFIE can be specified in the SSM-X model.

Besides, as in BOE, the core model must be completed with optimising model (GEMBI) to cofirm the results of long-term path pattern derived from the core model, and with short-term indicator models to confirm short-term projection. The description of one alternative model architecture that can be applied is as follows:

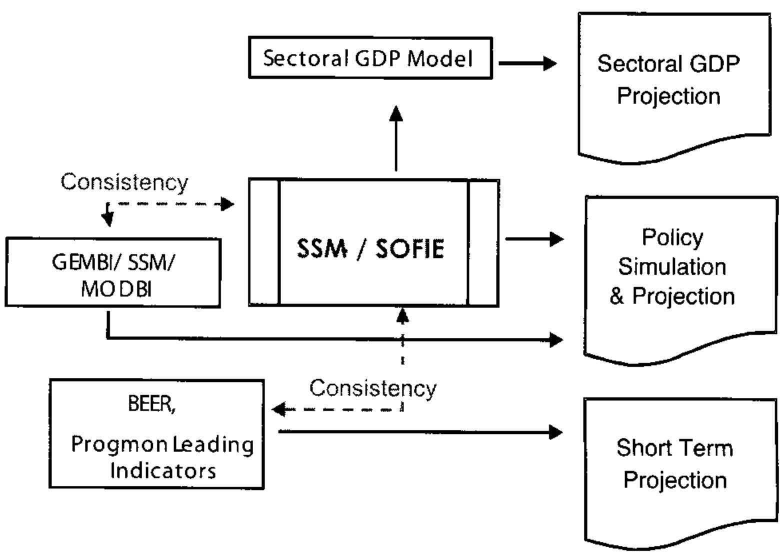

Diagram 7: The Plan of Bank Indonesia's Model Architecture

It must be noted as well that, although BOE has a core model that can be used for most of the policy analysis and projections, it is realized that one model only is incapable/inadequate for addressing all problems associated with the process of policy formulation, for example how to assess the effects of WTC 911 tragedy or Iraq war. A specific model must be built to review such effects. Besides, the possibility of some models to formulate alternative policy must also be reviewed. A series of results can be used as indicator for the magnitude of effect of uncertainty and can function as measurement of risk that may occur in relation to the attainment of its baseline projection.

3. Validity of the Model

To check the validity of a model is simply to test the predictive power of that particular model in forecasting. A good and reliable model of course should show a consistent accuracy over a reasonable long period of time. Extreme deviations of the forecasted values from the actual generally will indicate the low predictive power of the model. For this purpose, the most common validity tests are RMSE, MAE, MAPE and U-Theil. Those kind of methods are commonly used to test the within sample forecast. Meanwhile, the validity of the out of sample forecast can be examined through comparing the inflation outcomes and other endogenous variables with their adjusted forecast based on actual path of exogenous variables.

1) Within Sample Forecast

The table below shows the validity tests for each model that are used in BI's inflation forecasting system. The test is mainly focused on the capability of each model in forecasting three main economic indicators, namely inflation, GDP growth and exchange rate. The test is separated into full sample period of 1990:1 to 2002:4 and the period after the forecasting system has been used (2000:1 to 2004:4). Moreover, the test also compares the accuracy between forecasting with and without using the inflation forecasting system.

Table 1. Validity test of Various Models in period 1990:1 to 2002:4

Variable	Mean	MODEL	Validity			
			MAE	RMSE	MAPE	U-Theil
GDP Growth	4.03%	SSM SOFIE MODBI	2.15 3.23 0.75	2.87 4.30 1.93	0.631 0.806 0.353	0.210 0.290 0.126
CPI Inflation	14.38%	SSM SOFIE MODBI	1.96 5.51 3.13	2.39 7.00 5.41	0.481 0.707 0.906	0.053 0.159 0.125
ER Exchange Rate	5,596.95 Rp/USD	SSM SOFIE BEER	920.98 1,400.57 419.37	1,606.00 1,723.30 667.62	0.324 0.397 0.260	0.118 0.146 0.051

Table 2. Validity test of Various Models in period 2000:1 to 2002:4

Variable	Mean	MODEL	Validity			
			MAE	RMSE	MAPE	U-Theil
GDP Growth	3.99%	SSM SOFIE MODBI	2.53 4.67 1.50	3.02 5.43 1.88	0.785 1.057 0.628	0.454 0.439 0.223
CPI Inflation	9.27%	SSM SOFIE MODBI	1.44 3.49 3.43	1.69 4.03 3.97	0.598 0.434 0.585	0.078 0.192 0.165
ER Exchange Rate	9,333.96 Rp/USD	SSM SOFIE BEER	2,502.51 2,524.47 392.80	2,782.55 2,801.00 547.27	0.518 0.337 0.205	0.131 0.113 0.030

The two tables above shows how the validity tests are conducted when each model is used independently of each other for the full sample period of 1991 – 2002 as well as during the last three year (the second table). In Table 1. it shows that during the last three years, the predictive power of all models (SSM, SOFIE, MODBI) in forecasting the GDP growth and the exchange rate is declining. However, the models did a better job in forecasting inflation during the same period.

The main reason behind the declining forecasting power of the models in forecasting GDP growth was that the models used the forecasted exchange rate produced by each model endogenously as input in their calculations. This points to the indentification of the need to refine the exchange rate equation in the models to make it perform better. Interestingly, however, the declining in GDP growth and exchange rate forecast capability does not cause the declining in inflation forecast capability, especially for SSM and SOFIE models. In term of MAE and RMSE, the result shows that SSM and SOFIE indicate a better result in forecasting inflation. It is due to the utilisation of administered prices variable as the explanatory variable in those models, which apparently became the main source of inflation pressure in Indonesia during the last three years. On the contrary, in term of MAPE and U-Theil, the performance of inflation forecast has become worse due to the fact that the average inflation during those period was much lower than the period before.

Table 3 and 4 present the outcomes of a different exercise when the exchange rate in all the models was changed to be exogenously determined variable, using the BEER results. Furthermore, SOFIE and MODBI will predict the GDP first, and subsequently used as inputs into the SSM. Using this system, the forecasting power of the models improves in predicting both GDP growth and inflation. The weakness of the macro models in forecasting exchange rate, which has caused the low forecast capability, apparently can be covered by the BEER model which has better performance in forecasting the exchange rate. The significant improvement in GDP growth forecast indicates that the accuracy of exchange rate forecast is important. Meanwhile, the slightly improvement in inflation forecast indicates that there may be other

Table 3. Validity test of Inflation Forecast System's Models
(1990:1 to 2002:4)

Variable	Mean	MODEL	Validity			
			MAE	RMSE	MAPE	U-Theil
GDP Growth	4.03%	SOFIE MODBI	2.28 0.53	2.94 1.32	0.677 0.297	0.198 0.086
CPI Inflation	14.38%	SSM	1.62	2.05	0.519	0.045
ER Exchange Rate	5,596.95 Rp/USD	BEER	419.37	667.62	0.260	0.051

Table 4. Validity test of Inflation Forecast System's Models
(2000:1 to 2002:4)

Variable	Mean	MODEL	Validity			
			MAE	RMSE	MAPE	U-Theil
GDP Growth	3.99%	SOFIE MODBI	2.24 0.72	2.11 0.73	0.735 0.437	0.173 0.088
CPI Inflation	9.27%	SSM	1.26	1.50	0.581	0.072
ER Exchange Rate	9,333.96 Rp/USD	BEER	392.80	547.27	0.205	0.030

variables besides the GDP growth and the exchange rate, which may be more important in affecting inflation during the period.

The above example illustrates the gains that we can get by designing a forecasting system to increase the predictive power of the whole models. Another strategy that can also be used is to take a weighted average of forecasted values of various models. The weights will be determined by the statistical properties of the model (such as Akaike Information Criterion). The better is the model in predicting the required variable, the larger the weight should be given to the model.

2) Out of Sample Forecast

The result of out of sample test is a more reliable means in assessing the predictive power of forecasting than in-sample forecast test. The test not only evaluates the specification and the parameter of the model, but also the accuracy of predicting some exogenous variables assumptions. The first step of testing the validity of out sample forecast is to compare the outcome of endogenous variable with the forecasted values which is based on some preliminary assumption of exogenous variables' path. Afterward, we compare the forecasted values, which are based on actual path of exogenous variables, with the actual path of endogenous variables.

Table 5 below exhibits an example of out of sample forecast test in forecasting process of Indonesia's CPI inflation for the year 2000, 2001 and 2002. The test is applied to SSM as the main model in producing inflation forecast.

Table 5. Out Sample Forecast Test of Inflation Forecast System's Models (2000 to 2002)

Out Sample Forecast	2000	2001	2002
Inflation Projection (YoY%) :			
Based on assumptions & projection of variables at the end of previous year	7.11	9.5	10.06
Based on some actual data	8.81	12.03	10.14
Actual Inflation (YoY%)	9.35	12.56	10.03
Deviation :			
Based on assumptions & projection of variables at the end of previous year	2.24	3.06	-0.03
Based on some actual data	0.54	0.53	-0.11
Main Variables :			
Asumption & Projection at the end of Previous Year			
Exchange Rate (Rp/USD)	7,000	8,000	10,000
GDP growth (%)	3-4	4.5-5.5	3.5-4.5
Mo growth (%)	11%	11-12%	14-15%
Administered Prices Contribution (%)	2.11	2.5	2.57
Actual Data			
Exchange Rate (Rp/USD)	8,343	10,267	9,350
GDP growth (%)	4.8	3.5	3.4
Mo growth (%)	17%	18%	10.5%
Administered Prices Contribution (%)	3.42	3.83	3.31

The test result shows that SSM as the main inflation forecasting model were able to produce a quite accurate inflation forecast in the last three years. It can be seen in the deviation between actual inflation and forecasted inflation (based on actual data) that generaly has a small deviation (absolute average=0,4%). However, this indicator is not enough to serve as an accuracy indicator in predicting future inflation. To forecast the future inflation we have to predict some main variables which have an influence on inflation. The test shows that inflation projection, which is based on assumption and projection of main variables at the end of previous year, has a large deviation compared to the inflation outcome (absolute average=1.8%). It is mostly due to a large deviation in predicting two main exogenous variables in SSM, which are exchange rate and administered prices contribution on inflation. However, the exchange rate and administered prices forecasting model might not be fully responsible for the deviation because there were high political uncertainty during 2000 and 2001 that lead to the volatile exchange rate movement and uncertainty to government budget.

4. Adjustments to Model Results

The final stage of forecasting process is to look at the model results carefully. Apart from the exact nature of the model results, an experienced forecaster will never rely blindly on what the models produce. This is obvious for some, but it may also be hard to be accepted by others.

Nevertheless, one must realise that economic model is only mechanical tools which are not perfect in capturing the real world. Imperfections can originate from measurement errors and incomplete information when setting and collecting the assumption of exogenous variables of the models. New information is sometimes available after the forecasting process has been done. Thus, making adjustments based on forecaster's judgment so as to make the forecast more accurate and reliable is a fact of life as forecasters.

The common practice in Bank Indonesia of implementing judgment is to use "adjustment factors" or "add factors"[10]. Experienced forecasters will take the historical actual data as given and try to impose the model to produce the actual data, thus generating the historical error terms of the model. These error terms will give valuable information on the behavior and the accuracy of the model in forecasting out of sample period. Adding zero error term in forecasting of course may some time be sufficient when no other information is available. However, knowing the fact that it is almost impossible to have a zero error term in forecasting, we may gain more by utilising the information we have gathered and incorporating it into the model forecast through adding

10. This is actually the residuals (error term) of the equations in the model.

some "add factors". Indeed, the question of how to set "add factors" becomes very subjective. Therefore, it depends strongly on forecaster's experience and understanding of statistical behavior and the working of the whole economy as a system.

Experience so far suggests that the most recent residuals usually provide newer information that can be used to improve the forecast. In setting residuals for any endogenous variable in the forecast period, forecasters have to exercise their wisdom. If the current residual is considered large, was it a purely random error that can be reversed in the forecast? If yes, forecaster is more likely to set zero residual for the forecast horizon. If the forecaster think that the recent residuals reflect certain trends, in this case the best strategy would be to set non-zero residuals in the forecast horizon that bear relationship to the residual in the recent period. As an example, some hints on setting out-of-sample add factor is explained below:

- *Technical approach.* Technically, the add factor value should be set to zero whether directly in period t+1 or in longer period (t+n), depends on the previous movement of the add-factor. If the previous movement shows an increasing or decreasing trend, zero add factor can be set in longer period (t+n) base on forecaster's believe. Making a linier trend (gradually move to zero) is the easier way.

- *Economic sense.* If forecasters have a future view about certain information or economic variable, especially when the information can not be captured in the model, one can set the add factor by non-zero value. For example, forecasters may have a view that the future price setting behavior becomes more efficient as the government reduces market distortions in the foreseeable future. Given this view, forecasters may believe that the future inflation rate will be lower than what being forecasted by the model, so that forecasters could set a non zero add factors in the inflation equation.

5. Maintaining the Models

Maintaining the models is the process of keeping the model up-to-date so as to maintain and enhance the predictive power of the model. In general, activities involved in the process of maintaining the model are re-estimating some of the equations and refining the data used by the models. The declining predictive power is naturally the main reason behind the need to re-estimate some of the equations. Periodically, the validity of the model should be evaluated. However, there is no explicit threshold that can be used as a benchmark to do so. Therefore, model adjustment is often decided after the validity test keeps on showing worsening result. Afterwards, the source of worsening result has to be first identified to give guidance regarding which block or which equation in the model has to be adjusted. The validity test discussed in previous section can be used as an example. The test shows the worsening in GDP forecast which caused by the weakening of exchange rate forecast. So, the model adjustment should be more focused on the exchange rate equation.

The availability of a new concept or new empirical evidence usually leads to adjustment of the models. For example, the use of a new method in calculating the Indonesian output gap, which empirically shows a more robust result, suggest that adjustment is needed in the model. Another example, the study of the exchange rate passthrough found that the exchange rate movement has an asymmetric impact on inflation. Therefore, the model has to be adjusted to incorporate this new finding.

BI always evaluates its models performance and maintains them as a supporting tool in policy decision. All BI's models that are discussed in the paper had been adjusted to make them more reliable whether as a tool of forecasting or policy simulation. Relatively, MODBI as a pioneer model, which was constructed before the crisis in 1998 is such of model that had a lot of adjustment. Several equations in this model could not capture the 1998 structural break. Some equations were successfully modified and work on the others are still in progress. Therefore, since some equations have not been re-estimated, they are represented by the outcomes of other models. However, others model that have captured the structural break have also been modified in order to increase the accuracy.

While updating the data is a common practice, the process of adjusting the model depends on conditionality and modeler confidence. The model can be adjusted by using a simple method or a complicated one. In sequence, the adjustment starts from adjusting parameter, either using judgement or calibration method. Furthermore, it can also be done with re-estimating the equation, which can start from a single equation, multiple equations or all the equations in the model. Some conditionality that is mostly used to decide whether the model has to be adjusted are: the availability of the data, validity of the model, and the availability of new concept or new empirical evidence. However, in the end, it is up to the modeler judgement whether a model needs to be adjusted or not.

The availability of the data of course has to be contemplated when the model is constructed. However, sometimes things can happen such that the provision of the data is discontinued or historically changed in previous years by the data supplier. In our case, it did happen in Indonesia's CPI data. Since the end of 1999, BPS (Central Bureau of Statistic) excluded the city of East Timor as one of 44 cities that calculated in CPI basket due to the independence of East Timor. BPS then revised CPI data, dated back to 1996. Theoretically, this changes caused serious problem, since data prior to 1996 is no longer comparable. Fortunately, the model did not have to be re-estimated since the contribution of inflation in East Timor was insignificant.

IV Closing Notes

To support the implementation of a full-fledge IT framework, Bank Indonesia has been concentrating on enhancing its inflation forecasting capability as one of important operational aspects in this framework. Increasing the accuracy of inflation forecast has been seen as strategic as it can improve the Bank's credibility. Such efforts have been done through advancing forecasting techniques and modifying various models. Through the application of better coordination among forecasters and interconnection among models, so far the results are encouraging.

The future system of inflation forecasting in the transition period of IT framework in Bank Indonesia will be relying on four macroeconometric models (SSM, SSMX, SOFIE and MODBI) serving as joined core models. They will be complemented by GEMBI as an optimizing and policy simulation model as well as several partial models as the auxiliary and satelite models. One of quarterly macroeconometric models will be further enhanced to be a single core model in the established period of IT framework.

Nevertheless, as mentioned earlier, these models are only mechanical tools. They can never produce better and accurate results unless they are handled with skills and care by the people behind them. ***Models do not produce forecasts, people do !*** Therefore, the key success factor in producing highly credible and reliable inflation forecast will be very much depend on the strategic role of a high-skilled forecasting team in the decision making process of monetary policy.

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Appendix

Bank Indonesia's Inflation Forecasting Model (Small Scale Macromodel or SSM)

Bank Indonesia has developed a small macroeconomic model (BI -SQM) in order to forecast the inflation better and consistently. This model is a simultaneous quarterly model consisting of the following equations: (a) output gap, (b) aggregate demand, (c) real money balance, (d) the Phillips curve, (e) import price, and (f) exchange rate. The system is closed by a monetary policy rule directing the monetary authority in controlling inflation as its ultimate target.

The output gap equation below is formed as a function of economic growth, short term interest rate and oil prices

$$Y\text{-}Y^* = \alpha 1 + \alpha 2\ \Delta Y - \alpha 3\ i_t + \alpha 4\ o_{t-3} + \alpha 5\ seasonal\_fac. \quad (1.1)$$

As real output growth exceeds its potential demand pressure will arise, output gap will be positif. Demand pressures are also directly affected by higher consumption stimulated by the substitution effect of changes in short term interest rate. In addition, changes in oil price affects the revenue of oil export as a component of GDP. Deviation between the actual oil price and that assumed in state budget affects the output gap. It will be positive at the time the actual oil price is greater than its price assumption in state budget.

The aggregate demand is constructed as a function of the growth of government consumption, short term interest rate, exchange rate, real money balance and oil price variables:

$$\Delta Y = \alpha 5 + \alpha 6\ \Delta y_{t-1} - \alpha 7\ i - \alpha 8\ e + \alpha 9\ \Delta(m_t - p_t) + \alpha 10\ o_t \quad (1.2)$$

The negative effect of exchange rate on GDP growth needs to be explained further. Since the crisis, depreciation of the Rp seemed to have contractionary effects as it increases the burden of external debt repayments thus reducing the cash flows of many companies as well as state budget, while it also depresses demand for import leading toward less production as many industries apparently depend heavily on imported machinery and materials.

Real money balance equation is a function of income level, inflation, and interest rates (short term SBI rate and investment lending rate), Real money balance is negatively affected by interest rate and inflation and positively correlated with income level.

$$m_t - p_t = \alpha 11 + \alpha 12 m_{t-1} - p_{t-1} + \alpha 13 Y_t - \alpha 14\ \Delta p_t - \alpha 15\ \Delta\ i_t \qquad (1.3)$$

A Philips curve equation below describes the trade off between output and inflation:

$$\Delta p = \alpha 17 + \alpha 18\ \Delta p_{t-1} + (1 - \alpha 18)\ \Delta p^* + \alpha 19\ Y_t - Y^*_t + \alpha 20\ \Delta wpi \qquad (1.4)$$

Besides the effect of aggregate demand on prices, this equation also incorporates supply side pressures on inflation as represented by the growth of import-wholesale price index. This pressure is influenced by depreciation or appreciation of Rupiah and inflation rates in several Indonesia's main trading partners:

$$\Delta wpi = \alpha 21 + \alpha 22\ e + \alpha 23\ \Delta p' \qquad (1.5)$$

The simple exchange rate equation below represents the dynamics of exchange rate as explained by interest rate differentials and a dummy variable representing other variables that are not directly affected by monetary policy.

$$\mathbf{e} = \alpha 28 + \alpha 29\ \text{dummy} - \alpha 30\ \text{id} \qquad (1.6)$$

The simultaneous system is then closed by a policy rule commonly called the *inflation forecast with contamporenous output gap rule* which directs monetary authority in controlling inflation. This rule suggest that monetary policy should react against discrepancies between forecasted inflation and inflation target and between actual output and potential output.

$$i = \alpha 24 + \alpha 25 i_{t-1} + \alpha 26\ (\Delta p - \Delta P^*) + \alpha 27\ (Y - Y^*) \qquad (1.7)$$

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