RBI-MSE Joint Initiative on Modeling the Indian Economy for Forecasting and Policy Simulations

I. Collaboration with RBI

Beginning October 2008, the Reserve Bank of India and MSE will start collaborating for building a Macro Econometric Model of the Indian Economy. This work will be guided by an Advisory Committee headed by Dr. C. Rangarajan. This initiative provides an institutional basis for building and maintaining a Macro Model of the Indian economy. It aims at building a Core Model and a number of satellite models for different sectors of the economy. The project initially is for five years and teams both from the MSE and the RBI will be working on it. It will take into account the latest developments in modeling methodologies for estimation and forecasting.

II. Introduction to Macro Modeling

Macroeconomic modeling, because of its capacity to capture complex and dynamic interrelationships among economic variables, is a powerful analytical tool that can be useful for central and sub-national governments, the central bank, and other major stakeholders in the economy including businesses and investors, domestic and foreign, and institutions handling inter-governmental fiscal transfers. It provides a suitable analytical vehicle for addressing contemporary issues like tackling inflation, India's growth prospects in the medium to long term, examining inflation-growth trade-offs, impact of inflationary expectations, managing public debt and deficit at sustainable levels, and determining permissible levels of seigniorage. These issues can be examined after taking into account both the internal and international trends in a consistent framework.

Macroeconomic modeling techniques including specification, estimation, and theoretical underpinnings have been evolving at a rapid pace. In India, while there has been a tradition of building models going back to about five decades, except for a few, these models have remained one-time exercises. With some exceptions, macro modeling has not been undertaken at the level of institutions as on-going exercises. The evaluation of forecasts has also not been undertaken on a regular basis.

In the western world, the initial wave of constructing large macro econometric models in the sixties and seventies was followed, in the eighties and nineties, with disenchantment with these due to poor forecasting performance and usability for policy formulation following the Lucas (1976) critique. More recently, with the emergence of powerful non-structural methods of forecasting including time series and vector autoregression (VAR) models and new strategies for constructing structural models moving away from the 'system-of-equations' (SOE) approach to micro foundations and modeling approaches like dynamic stochastic general equilibrium (DSGE) modeling, Vector error correction models (VECM) and structural cointegrating VAR models, there is now a resurgence of modeling for forecasting and policy analysis.

III. Macro Modeling: Recent Theoretical Perspectives

a. Structural Macroeconomic Models

Structural macro modeling can be traced back to the pioneering work of Tinbergen and Klein and subsequent work at the Cowles Commission. Keynesian macroeconomic forecasting models, based on income-expenditure systems, a set of stochastic behavioral and/or technological equations complemented by suitable identities, enjoyed a golden age in the 1950s and 1960s. During these years, these macro economic models (MEMs) progressively grew in size and sophistication of estimation. Some of the important examples of such large scale structural MEMs are Federal Reserve Board's Models, Fair's model of the US economy, Murphy's Model of the Australian economy (1988, 1992), London Business School Model (LBS), National Institute of Economic and Social Research (NIESR), and HM Treasury (HMT) models of the UK economy.

The popularity and usability of structural large scale MEMs waned during the 1970 and 1980s. Part of this decline was due to growing dissatisfaction with the Keynesian theoretical underpinnings of these models, including poor micro foundations and inadequate expectational specifications. Partly, the disenchantment arose due to their poor forecasting performance where small non-structural models like VAR routinely gave superior forecasting performance. Many predictive failures were due to structural changes and regimes shifts. Four important methodological critiques are worth noting, as discussed below.

First, following the Lucas (1976) critique, also known as the policy irrelevance doctrine, the usability of MEMs as a guide to policy formulation was seriously questioned. Most models were built on the assumption of a given structure and stability of parameters. In so far as economic agents were able to revise their expectations based on information including the model forecasts, and adjusted their behavior accordingly, leading to changes in model parameters, model forecasts were belied as a logical outcome of their own predictions. While the Lucas critique is theoretically appealing, its empirical relevance has since been questioned (see, for example, Eriksson and Irons, 1994 and Fair, 2004) and the results on its importance at best give mixed evidence (VanBergeijk and Marc Berk, 2001). The Lucas critique remains a milestone in macro modeling literature and more and more models have started incorporating adequate mechanisms for forming expectations including rational expectations.

Secondly, Sims (1980) raised serious doubts about the traditional modeling of behavioral relations, which had been based on extremely restrictive assumptions. Sims called these as ‘incredible’ restrictions on the short-term dynamics of the model. Sims’ alternative modeling strategy led to the Vector Auto Regression (VAR) models. While VAR models usually produce unconditional forecasts that might outperform, under certain conditions, forecasts generated from large macro economic models or other univariate models, their usability for policy analysis is limited.

Thirdly, greater attention was paid to the treatment of non-stationarity in macro variables. This led to modeling techniques involving cointegration and provided a framework for model dynamics to evolve around long term equilibrium relationships. This new emphasis particularly followed from the work of Nelson and Plosser (1982) who showed that many important macroeconomic variables in the US economy contained unit roots. Some of the pioneering work regarding cointegration and error correction models came from Engle and Granger (1987).

Finally, large econometric models also suffered from what is known as the 'curse of dimensionality'. By including too many variables, often accidental or irrelevant data features are embodied into the model. The chances of including features that are not likely to remain similar to the sample period increase, and errors multiply due to cross-equation linkages. Further, parameter estimates may be poorly determined due to large number of variables and high probability of correlation. Clements and Hendry (1995) observe: ".. parameter estimates may be poorly determined in-sample due to the sheer number of variables, perhaps exacerbated by the high degree of collinearity manifest in the levels of integrated data." As such parsimony is considered a desirable feature of macro modeling. It is worth recognizing, however, that one of the foremost experts on macro modeling, namely, Klein, continues to put faith in large size models arguing (e.g., Klein,1999) that small models cannot capture the complex nature of an economy and that this may lead to misleading policy conclusions.

One response to the criticism of the Keynesian system-of-equations approach was to incorporate rational expectations in the econometric models. Notable efforts of this genre were by Fair (1984, 1994) and Taylor (1993) who also undertook rigorous assessment of the model fit and forecast performance. Models in the Fair-Taylor mould are now in use at a number of leading policy organizations (see, e.g. Diebold,1998).

In spite of their failures, these large models left a rich analytical, methodological, and empirical legacy. They spurred the development of powerful identification and estimation theory, computational and simulation techniques. As observed by Clements and Hendry (1995): “ Formal econometric systems of national economies fulfil many useful roles others than just being devices for generating forecasts; for example, such models consolidate existing empirical and theoretical knowledge of how economies function, provide a framework for a progressive research strategy, and help explain their own failures”.

One outcome of the critique was the recognition for the need for separating models that could be used for unconditional forecasting vis-à-vis others that can be used for policy analysis. Clements and Hendry (1995) suggest that it is useful to distinguish between characteristics of models that are to be used for forecasting alone as compared to those that may be used for policy analysis. In the case of forecasting, parsimony may help by excluding those relations that are not likely to persist in the forecast period. Sometimes models focused on forecasting exclude long-term relations that may be crucial for policy formulation. The *ex-ante* desirability of any policy depends on its effects and on the baseline forecasts prior to its implementation. The timing of important policy changes can be improved by using such models. Stringent conditions must be satisfied to support policy analysis based on econometric models. First, it should be possible to specify the policy change in the model and policy variable should be ‘super exogenous’ in the terminology of Engle and Hendry (1993). In the case of weak exogeneity, the Lucas critique may yet apply if the expectation of policy change changes the behavior of the economic agents. In such cases, the effect of anticipated changes should also be modeled.

b. Non-structural Forecasting Models

Among models devoted entirely to forecasting, the tradition of using non-structural models, which had roots in works of Slutsky (1927) and Yule (1927) pre-dating Keynes, underwent a strong reemergence in recent times. Slutsky and Yule had argued that simple linear difference equations, driven by purely random stochastic shocks, provide a powerful tool for forecasting economic and financial time series. While autoregressive processes modeled current value of a variable as weighted average of its own past values plus a random shock, Slutsky and Yule also studied moving average processes where the current value could be expressed as weighted average of current and lagged random shocks only. In more recent times, work on autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) modeling developed at a rapid pace with the pioneering work of Box and Jenkins (1970). Although Box-Jenkins framework dealt primarily with univariate modeling, many extensions of the Box-Jenkins models involved multi-variate modeling and notably Sims advocated the use of Vector Autoregression (VAR) models as a less restrictive alternative to structural econometric modeling. Sims (1972) had argued that the division of variable into endogenous and exogenous variables, as done in the structural models, was arbitrary and VAR models could avoid that by treating all variables as endogenous. In the VAR model, cross variable effects are automatically included as each variable is regressed on its own lagged value and lagged values of all other variables. It is straightforward to estimate VAR systems as one equation at a time as estimation using OLS has been established to be efficient. These models can be taken as unrestricted reduced-form models. More recent variants allow for symmetric and asymmetric variants. Bayesian VAR models allow for prior restrictions.

Non-structural models have been used as a powerful tool for forecasting. These are also convenient, as no independently predicted values of exogenous variables are needed to generate forecasts as in the case of structural models. However, as these models produce unconditional forecasts, these are not directly useful for policy analysis.

IV. Modeling the Indian Economy

Macro econometric modeling of the Indian economy started in late 1950's but underwent extensive growth since 1960's. Extensive surveys of the model building endeavor in India have been undertaken from time to time. Some examples are Bhaduri (1982), Chakrabarty (1987), Jadhav (1990), Krishna, Krishnamurty, Pandit, and Sharma (1991), and Pandit (1999). Two recent papers are: Pandit (2001) and Krishnamurty (2002). In a recent review of macroeconometric models for India, Krishnamurty (2002) divides these models into five generations covering almost a period of five decades. In spite of this rich heritage of macroeconomic modeling, most of these remain structural models in the Keynesian tradition and therefore subject to almost all the criticisms of the structural models that we have reviewed so far. Two of the prominent international efforts at modeling the global economy through joining individual country models, namely Project LINK and Fair's multi-country model, both include a country model of the Indian economy.

In appreciation of the model building effort in India, one might recognize that many of these came from individual efforts rather than having any institutional support. In the initial years, there were also major data problems. No meaningful quarterly or sub annual series were available except for a few sectors. Even in the case of annual data, there were periodic reviews of the base year and estimation methodology making comparability extremely difficult. Many of the earlier models were therefore estimated on the basis of extremely small samples with data covering a period of 20 to 30 years. Modeling of the Indian economy has been particularly difficult because of structural changes. Most models had assumed stable parameter values and therefore it was quite difficult for them to capture structural changes except by some ad hoc adjustments.

A large number of models covering the period at least until the eighties were based on estimates where proper testing of unit roots and stationarity of series was not done. Many of those models therefore had a weak estimation basis. Even now, very few structural models have been specified and estimated using co-integration and error correction mechanisms. The value of the long tradition of model building in India, however, lies in having provided a rich understanding of sectoral and inter-sectoral features of the economy. Some of the data constraints are now less restrictive with many important macro time series stretching over 50 years or more. Most models that incorporate policy analysis also became methodologically dated because of inadequate specifications of the impact of expectations regarding policy changes on parameter values

In examining fiscal and monetary policy issues, some of the first models that recognized issues relating to government debt and its accumulation through fiscal deficit were Srivastava (1981) and Rangarajan, Basu and Jhadav (1989, 1994). These models recognized the importance of the government budget constraint and the differential impact of financing government fiscal deficit that is monetized or based on borrowing from domestic markets or external sources. In fact, Rangarajan et al were the first to explicitly discuss the issue of debt sustainability and the importance of fiscal and primary deficits. Later models like those by Krishnamurty and Pandit, in the several versions of modeling efforts at the IEG/ DSE, have analyzed the government sector in detail. Issues of debt sustainability and strategies of supporting aggregate government demand financed by government borrowing are some of the critical and contemporary policy issues that require to be addressed thorough a macro model.

V. New Wave of Structural Modeling

Writing in 1995, Pesaran and Wickens had identified five major approaches to macroeconomic modeling: the traditional Cowles Commission structural equations approach, unrestricted and Bayesian VARs, structural VARs, linear rational expectations models, and the calibration approach associated with real business cycle models. Many models are eclectic using a combination of elements drawn from different approaches.

As part of the new wave of structural modeling, some of the techniques that are now emerging address some of the basic difficulties noted with the Keynesian type system-of-equations models. In particular, those models were criticized for not catering to basic behavioral determinants like taste and technology and based on postulated decision rules. As such, although called structural models, these lacked depth in their structural specification. One of the first such efforts was made by Lucas (1972) based on a dynamic stochastic model that provided for fully articulated preferences, technologies and rules of the game. This type of modeling was given the name of dynamic stochastic general equilibrium (DSGE) modeling. These models avoid the Lucas critique as these are based on fully specified stochastic dynamic optimization as opposed to any reduced-form decision rules that had characterized the earlier genre of Keynesian type structural models. The new generation of models was developed for direct practical applications.

One well-known example is that of Kydland and Prescott (1982), which used DSGE modeling to argue that a neo-classical model driven by technology shocks could explain a large fraction of US business cycle fluctuations. These models, also initially called real business cycle models, are combinations of preferences and technologies. In general, in the DSGE models, while preferences are quadratic and yield tractable optimizing decisions, technologies are linear, thereby giving rise to linear-quadratic models. Optimizing behavior such as those of consumers and investors under quadratic preferences yields decision rules that are stochastic and linear functions of other variables. As such the decision rules conform to the VAR type of specifications subject to restrictions that arise from theory. Kydland and Prescott (1982) used non-linear quadratic models so that non-linearity in technologies can be accommodated. Although solving these models is not a straightforward exercise, in most cases these are approximated by vector autoregressions. In estimating the DSGE models, formal estimation is often combined with calibration methods, a good description of which is available in Kydland and Prescott (1996). More recent arguments favor formal estimation of the DSGE models and search for best fitting parameters. Maximum likelihood estimators have been the most preferred estimators. Current work on DSGE modeling aims at accommodating heterogeneity in agents using representative agents and suitable aggregator functions. The analysis has to be developed to a level that it can suitably address the Lucas critique. One characteristic of DSGE models is their parsimony.

Another important modeling strategy is referred to as ‘Structural Cointegrating VAR Approach’ (SVAR). This approach also has transparent theoretical foundations in regard to the underlying behavioral relationships. It is based on loglinear VAR model estimated subject to long run relationships based on economic theory. In the presence of unit root in different macro time series, the long-term relationship is derived on the basis of cointegrating relationships among variables, which provide the relevant restrictions on the VAR.

Making an assessment of the future of macroeconomic modeling and forecasting, Diebold (1996) writes: "The hallmark of macroeconomic forecasting over the next 20 years will be a marriage of the best of nonstructural and structural approaches, facilitated by advances in numerical and simulation techniques that will help macroeconomics to solve, estimate, simulate, and yes, *forecast* with rich models".

It is clear that while macro modeling has had a rich history in India, considerable new effort is required in the context of the development of new modeling techniques and also focus on modeling that can direct and practical policy applications.

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