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Publication Details

Valadkhani, A, *Macroeconometric Modelling: Approaches and Experiences in Developing Countries*, Working Paper 05-10, Department of Economics, University of Wollongong, 2005.

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**University of Wollongong
Economics Working Paper Series
2005**

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WP 05-10

May 2005

MACROECONOMETRIC MODELLING: APPROACHES AND EXPERIENCES IN DEVELOPING COUNTRIES*

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Abstract

This paper selectively reviews various approaches of macroeconomic modelling and highlights some important lessons from more than half a century of model-building particularly in the context of Asian countries. Addressing several issues discussed in this paper can improve the use of macroeconomic models (MEM) in forecasting and policy analysis in the foreseeable future. This survey shows that most MEMs in developing countries are either becoming smaller in size or not being subject to a thorough diagnostic investigation. In the specification of models one should consider the interplay among macroeconomic policies of different countries via international trade and global financial markets. It is argued that the Project Link and the Fair multi-country model are two initiatives in the right direction. It also appears that with advancement of econometric "know-how", the disparity of opinions between advocates and critics of macroeconomic modelling can be narrowed.

JEL classifications: B23; C52; C51

Keywords: Macroeconomic modelling, Asian Developing Countries

* The author wishes to acknowledge Professor Ronald G Bodkin, of the University of Ottawa, for his useful comments on a previous draft of this paper. The usual caveat applies.

MACROECONOMETRIC MODELLING: APPROACHES AND EXPERIENCES IN DEVELOPING COUNTRIES

1. Introduction

The use of macroeconomic models (MEMs) for policy analysis and forecasting has a tumultuous history since World War II when Marschak organised a special team at the Cowles Commission by inviting luminaries such as Tjalling Koopmans, Kenneth Arrow, Trygve Haavelmo, T.W. Anderson, Lawrence R. Klein, G. Debreu, Leonid Hurwitz, Harry Markowitz, and Franco Modigliani (Diebold, 1998). For a detailed account of the role of the Cowles Commission in macro modelling visit <http://cowles.econ.yale.edu>. Valadkhani (2003) reviewed the literature on macroeconomic modelling and highlighted some important lessons from more than half a century of model-building. The objective of this paper is to discuss the same issues but more focusing on macroeconomic modelling in Asian countries such as India and China.

It is useful to define a MEM at the outset. A crude definition of a MEM could be that it is a set of behavioural equations, as well as institutional and definitional relationships, representing the structure and operations of an economy, in principle based upon the behaviour of individual economic agents. Macroeconomic modelling is multi-dimensional and both a science and an art. Bautista (1988) and Capros, Karadeloglou and Mentzas (1990) have classified macroeconomic models into broad groups: MEMS and CGE (computable general equilibrium) models. Further, according to Challen and Hagger (1983, pp.2-22) there are five varieties of MEMs in the literature: the KK (Keynes-Klein) model, the PB (Phillips-Bergstrom) model, the WJ (Walras-Johansen) model, the WL (Walras-Leontief) model, and finally the MS (Muth-Sargent) model.

The KK model is mainly used by model builders in developing countries to explain the Keynesian demand-oriented model of macroeconomic fluctuations. They deal with the problems of short-run instability of output and employment using mainly stabilisation policies. The basic Keynesian model has been criticised as it does not consider the supply side and the incorporation of production relations. Furthermore, this modelling approach does not adequately capture the role of the money market, relative prices and expectations. As a response to the shortcomings associated with the KK model, the St Louis model was constructed by the monetarist critics (Anderson and Carlson, 1970) in order to highlight the undeniable impacts of money on the real variables in the economy.

The second type of MEM, the PB, emerged in the literature when Phillips (1954, 1957) used both the Keynesian and the Neoclassical theories within a dynamic and continuous time model to analyse stabilisation policy. Although the PB model is also a demand-oriented model, differential or difference equations are used to estimate its stochastic structural parameters. In essence, the steady state and asymptotic properties of models are thus examined in a continuous time framework. One should note that this modelling method in practice becomes onerous to implement especially for large scale models.

The third type of MEM, the WJ, can be referred to as a multi-sector model in which the economy is disaggregated into various interdependent markets, each reaching an

equilibrium state by the profit maximising behaviour of producers and utility maximising actions of consumers in competitive markets. Similar to an input-output (IO) approach, different sectors in the WJ model are linked together via their purchases and sales from, and to, each other. However, it is different from an IO model as it is highly non-linear and uses logarithmic differentiation.

The fourth type of MEMs, known as the WL model, has been widely considered as the more relevant MEM for developing countries (Challen and Hagger, 1983). The WL model incorporates an IO table into the Walrasian general equilibrium system, enabling analysts to obtain the sectoral output, value added or employment given the values of the sectoral or aggregate final demand components.

Finally, the foundations of the MS model are based on the evolution of the theory of rational expectations. The MS model is similar to the KK model in that they both are dynamic, non-linear, stochastic and discrete. But in this model the formation of expectations is no longer a function of previous values of dependent variables. The forward looking expectation variables can be obtained only through solving the complete model. The New Classical School demonstrated the role of the supply side and expectations in a MEM with the aim of highlighting the inadequacy of demand management policies. To this end, Sargent (1976) formulated forward-looking variants of this model which suggest no trade-off between inflation and unemployment in the short term, which is in sharp contrast to both the Keynesian and Monetarist modelling perspectives. The subsequent advances in the WJ and WL models resulted in the formulation of the Neoclassical CGE models which are based on the optimising behaviour of economic agents. CGE models are used to conduct policy analysis on resource economics, international trade, efficient sectoral production and income distribution (Capros, Karadeloglou and Mentzas, 1990).

The rest of this paper is structured as follows. The next section presents a concise historical review of the origins of MEMs in developing countries. The penultimate section of the paper derives some lessons from more than half a century experience that can improve the use of MEMs in policy formulation and forecasting in Asian countries. The last section provides some concluding remarks.

2. Macroeconometric Modelling in Developing Countries

Macroeconometric modelling has a long and interesting history. Tinbergen is regarded as a pioneer of macroeconometric modelling as he formulated the first MEM for the Dutch economy prior to World War II to assist the Dutch Central Planning Bureau in implementing their economic policies. Tinbergen was also famous for his seminal work in 1939 on business cycle analysis of the US economy (Bodkin, Klein and Marwah, 1991). This paper presents brief and selective issues of macroeconometric modelling in developing countries. For a comprehensive literature review of MEMs see Bodkin, Klein and Marwah (1986a, 1986b), Bodkin (1988a, 1988b), Bodkin, Klein and Marwah (1991) and Valadkhani (2003).

Macroeconometric modelling in developing countries has also a relatively long history. In fact, the persistent economic predicaments in many developing countries such as stagflation, trade and budget deficits, and enormous debt burdens led a significant

number of developing countries to use MEMs. See, *inter alia*, Ichimura and Matsumoto (1994) and Uebe (1995) for a long list of the estimated MEMs for a large number of countries. Uebe has also tabulated a useful summary and list of MEMs for 150 countries at <http://www.unibw-hamburg.de/uebe/modelle/titelseite.html>. One can select a particular country and view a list of the constructed MEMs for that country including the construction date, modellers' names, the type of model, the number of equations etc. For a number of models a neat list of estimated equations and the identities of the model together with the corresponding sources are also available in the pdf format in the Uebe website. Due to the lack of space, it is an impossible task to analyse the MEMs built even for a few countries. Therefore, our discussion is focused only on main common shortcomings plagued MEMs in most developing countries.

The first MEM for a developing country was constructed by Narasimham (1956) for India under the supervision of Tinbergen. The earliest models for developing countries were mainly small versions of the KK model capturing the demand side of the economy. ECAFE (1968) and UNCTAD (1973) constructed a series of MEMs for about 40 developing countries to assist them in forecasting the foreign capital needs of the member countries. These models were criticised by Shourie (1972) on the basis of three major deficiencies, *viz.*, insufficient sample size, multicollinearity, and mis-specification of the models. In a response to this critique, Sastry argued that the UNCTAD models "exhibit a fair measure of stability and provide a reasonable basis for projections" (Sastry, 1975, p.158). In fairness to Shourie's criticisms, it should be pointed out that these deficiencies may not only be true in the context of developing countries, but might also be relevant in the case of developed countries. Despite these problems, Sastry suggested that MEMs can be useful if the value of the key parameters are checked and compared with those of other countries with a similar economic structure.

Adams and Vial (1991) evaluate some simulations for the ten MEMs of the ten different countries (Brazil, Chile, Hong Kong, India, Korea, Mexico, the Philippines, Taiwan, Thailand, and Venezuela) and their findings are summarised below. First, inflation was found to be mainly a monetary phenomenon. Second, the effect of government investment on economic growth was less than that of the government consumption. This was obviously against the expected theoretical outcomes and it can be due to misspecification or the absence of appropriate linkages between investment and production capacity. Given the vigorous impacts of investment on both the supply and demand sides, Khayum (1991) argues that in any MEM for developing countries substantial attention should be placed on capital formation. Third, the simulation performance of the MEMs was more accurate in the short-term than the long term. Fourth, the majority of these models suffered from excessive "Keynesianism", which means the modellers gave insufficient attention to the role of the supply side in the long run (Adams and Vial, 1991)

As can be seen from the above discussion, there are some problems in the construction of MEMs which should be addressed. For example, Corden (1985) discusses the relevance of the recent developments in non-Keynesian public choice and rational expectations theories for the implementation in developing countries. But Seers (1963) criticised the application to developing countries of models which were appropriate for developed countries, since they had been designed for different purposes and totally different economic structures. A Keynesian MEM which is appropriate for developed

countries can also be relevant for developing countries provided that necessary modifications are undertaken particularly in the specification of investment and production functions (Klein, 1965, 1989a). In this regard, it is recommended that the equations for price, wage, interest rate and exchange rate, unemployment, channels of distribution and demographic characteristics should be specified more thoughtfully (Bodkin, Klein and Marwah, 1986b).

Economic development obstacles in most developing countries are not due to having adequate effective demand, but are associated with the supply constraints. Therefore, model-builders should take account of production inter-dependencies by incorporating an IO table. By incorporating a conversion matrix into a MEM, the supply side has not been neglected since both intermediate and final demand encompass demand for capital goods and other factors of production (Klein, 1965, p.323).

The availability of data in most developing countries is a restrictive factor, making model-building an arduous task since there are relatively few reliable databases and they are often subject to frequent revisions. For this reason, one should use robust and simple methods such as the 2SLS method which are not too sensitive to the quality of data (Klein, 1989b, pp. 297). If there is a measurement error in one of the variables in an equation, then the use of the 3SLS and FIML etc can spread the likely measurement errors to the other equations. Behrman and Hanson (1979) also argued that macroeconometric modelling is useful for developing countries if the appropriate modifications are undertaken. In their view, the use of a fixed and overvalued exchange rate is a clear example. In most cases when the financial sector in a developing country is modelled, interest rate is not always an appropriate variable to link the real sector to the financial sector. The use of some other variables as proxies like banking credit, output or inflation is more appropriate (Khayum, 1991).

During the last three decades, MEMs have been internationalised via Project LINK which was first operated at the University of Pennsylvania under the intellectual leadership of Nobel Laureate Lawrence Klein. In 1960 there were only 7 MEMs in this project but in 2003 Project LINK consisted of more than 250 participants and 80 MEMs of individual countries. (For more detailed account of the Project Link visit <http://www.chass.utoronto.ca/link/> or <http://www.un.org/esa/policy/link>). In Project LINK the world is treated as a closed system of several thousand equations which "allow trade, capital flows, and possible exchange rate and other repercussions to influence systematically the individual national economies" (Bodkin, 1988b, p.222). This system comprises a number of independent national and regional models that provide estimated equations for aggregate supply, aggregate demand, public sector revenue and expenditure, monetary variables, prices, international trade flows and the balance of payments. The national MEMs are then integrated into a global framework that is capable of generating internationally consistent forecasts for the world economy as well as for each member country or region.

More recently "the core research group at the LINK Centre is responsible for the international transmission mechanisms which operate through trade flows, price linkages, capital flows, interest rates, exchange rates, migration, technology transfers, and global commodity markets, as well as for the maintenance and operation of the fully linked world model. [The Project LINK Research Centre, *inter alia*, conducts research on important issues such as:] international economic volatility and national economic policies; trade

diversification and long-term growth; trade and investment in the Asia-Pacific area; global economic implications of multilateral disarmament; global economic and environmental effects of carbon taxes; regional trade arrangements and global economic development; regional savings-investment imbalances and world real interest rates; and debt relief for African developing countries” (<http://www.chass.utoronto.ca/link/>).

Another major step in the internationalization of MEMs was taken by Fair (2004) in his well documented and carefully executed multi-country model. Fair (2004) in his multi-country model (MC) has 39 countries (including India, Malaysia, Pakistan, the Philippines and Thailand) for which stochastic equations are estimated using the available (annual or quarterly) data for the 1959-2002 period by the 2SLS method. The U.S economy is modelled with 31 stochastic equations and there are also up to 15 equations for the other 38 countries. Given the increasing importance of trade and globalisation among countries, Fair has incorporated the trade share data (a 59 by 59 matrix) for 59 countries into his MC model. For 14 countries quarterly equations and for the remaining 25 countries annual equations have been estimated. Fairmodel is freely available on the internet at <http://fairmodel.econ.yale.edu/> and allows for everyone to conduct numerous counterfactual policy related “what if exercises”.

It should be noted that since the late 1970s, macroeconometric modelling has been subject to severe criticism predominantly on academic grounds. The major criticisms of the traditional MEMs based on the Cowles Commission approach has been classified by Pesaran (1995) into six issues: forecasting inadequacy; theoretical contrasts with rational expectations theory; structural instability (Lucas critique); arbitrary assumption of zero restrictions (*i.e.* causal ordering) or the endogenous-exogenous division of the model variables in order to pass the identification conditions; and finally the existence of the problem of unit roots and ignorance of cointegration and the time-series properties of the data.

The Lucas (1976) critique, *inter alia*, had a more powerful influence in decreasing the application of MEMs for policy analysis. The Lucas critique led to a new area of research which is known as analysis of "deep structural parameters" (Fair, 1987). It is mentioned that under alternative policy formulations, because all the economic agents base their decisions on the full information, "any change in policy will systematically alter the structure of econometric models" (Lucas, 1976, p.41). Therefore, it is highly likely that the estimated coefficients of a MEM will change as a result of agents anticipating and knowing policy measures.

Bodkin, Klein and Marwah (1986b, 1991) responded to these criticisms resorting to Eckstein's (1983) investigation of the DRI model and the reliable forecasting performance of MEMs, as investigated by McNees (1979) and Zarnowitz (1978). On the basis of these empirical investigations, they state that: "We feel that the track record of continuing macro-econometric modellers is not so bad as the occasional horror story of an unsuccessful forecast would suggest...Compared to their alternative (naive models, time series analysis of single series, or judgmental forecasts) the econometric models do reasonable well, particularly as the forecasting horizon lengthens" (Bodkin, Klein and Marwah, 1986b, p.50).

Klein (1989a) acknowledges the importance of the Lucas critique, but adds that: "I believe that there is more persistence than change in the structure of economic

relationships. The world and the economy change without interruption, but that does not mean that parametric structure is changing. Random errors and exogenous variables may be the main sources of changes" (p. 290). In a rebuttal to the theory of rational expectations and the Lucas critique, Bodkin and Marwah (1988a) draw attention to the irrational assumption of the rational expectations theory with respect to the complete access of the typical economic agent to the raw data and the true model of the economy. They contend that these assumptions are most unrealistic and cannot be accepted. Fair (2004) has already tested the rational expectations hypothesis and in most cases he has rejected it. Nevertheless, Bodkin and Marwah (1988a) acknowledge the New Classical School for raising such a vital issue, and suggest further clarification and research on expectations formation. MEMs with optimising agents have already adopted rational forward-looking expectations resulting in a set of Euler equations *e.g.* see Willman *et al* (2000) and Hunt *et al.* (2000) for models from the central banks of Finland and New Zealand, respectively.

As seen from the literature, the Lucas-type critiques resulted in an upgrading of the theoretical knowledge and in better empirical achievements by econometricians. This is to say, the significant advances in the macroeconometric literature including rational expectations theory, supply-side economic policy, and open economy macroeconomics have given rise to further research in this field.

3. Lessons from Past Experience

The new generation of modellers should take advantage of the current developments to build large scale MEMs and conduct various econometric diagnostic tests. These current developments consist of improvements in computational capacity, new developments in econometric methods, new macroeconomic theories and advances in the quality and availability of the required data (Bodkin, Klein and Marwah, 1988a, 1991). However, it is also argued that the analysis of the economy will be more difficult when there are numerous equations in the model, thus advocates of small scale modelling suggest that the small model can explain the economy more efficiently. Arguments from advocates and critics of large scale models can be found in Friend and Taubman (1964), Fair (1971, 1974), Kmenta and Ramsey (1981), and Klein (1989a). They argue that one needs to Keep It Sophisticatedly Simple (KISS). It is "much easier to see the forest when the trees are fewer" (Bodkin and Marwah, 1988a, p.301). However, Klein (1999) argues that small models cannot capture the complex nature of an economy and this may result in misleading policy conclusions. In addition, Bodkin, Klein and Marwah (1991) state that a complete model often encompasses three sub components, *viz.* national income, input-output and flow of funds. Thus a MEM becomes larger in size if the aim is to have a full model.

Intriligator, Bodkin and Hsiao (1996) assert that MEMs are useful in structural analysis, forecasting and policy evaluation provided that they are subjected to some parametric tests prior to and after the release. The tests they recommend, which are of paramount importance in evaluating the validity of MEMs, can be classified into two major categories: testing for individual equations of the model and testing for the full model (system) as a whole. The first category consists of four sub-tests: first, the standard t

and F tests to check for the statistical significance of the estimated parameters; second, testing for the expected theoretical signs of the estimated parameters; third, diagnostic tests for checking various violations of the classical linear regression model such as normality, autocorrelation and serial correlation, heteroskedasticity, functional form, etc.; and fourth, checking for the stability of the estimated equation by say the Chow or CUSUM tests to make sure the equation is stable over time.

The second category consists of three sub-tests: first, the dynamic tracking performance of the full model as a system or *gestalt* should be evaluated in terms of some goodness-of-fit statistics such as the Theil inequality coefficient, the root-mean-square error (RMSE) etc.; second, the dynamic response of the full model should be acceptable (*i.e.* the whole model should not exhibit explosive behaviour in terms of impact and interim multipliers and/or characteristic roots); third, before releasing a MEM and its results, the model-builder should check whether the resulting policy simulations are in line with theoretical expectations. The simulation results are not supposed to be counter-intuitive, but if they are, adequate interpretations should be provided.

According to many macroeconomic model-builders, to a large extent, the implementation of the above-mentioned requirements can settle the disparity of opinions between modellers and critics. However, critics of MEMs should recognise that, compared with the VARs and the calibration CGE models, macroeconomic modelling still remains "the most promising approach to understanding macroeconomic behaviour generally and is the most likely approach to provide a really powerful policy tool" (Hall, 1995, p.975). By no means does macroeconomic modelling at present appear to be weaker than before. On the contrary, it "has weathered these storms rather well; indeed, it has probably emerged stronger as a result of the fundamental revaluation of the subject that has resulted from these attacks" (Intriligator, Bodkin, Hsiao, 1996, p.9). In fact, there is now a growing interest in developing MEMs "with transparent theoretical foundations and flexible dynamics that fit the historical time series data reasonably well...[these models incorporate] the long-run structural relationships suggested by economic theory in an otherwise unrestricted vector autoregressive (VAR) model" (Garrat *et al.*, 2003, p.412).

Having said that, most MEMs for developing countries are not constructed this way. For example Krishnamurty and Pandit (1996) in their model of India's trade flows do not check any diagnostic check on the estimated equations. It appears that most recently constructed models are becoming smaller. Only a few modellers (such as Kalirajan and Bhide, 2003) are interested in constructing medium to large scale MEMs. Kalirajan and Bhide (2003) specify and estimate a model to examine the impact of selected policy reform measures (*e.g.* improvement in rural literacy and physical infrastructure; improvement in irrigation, the exchange rate depreciation and reduction in trade protection to the manufacturing sector) on India's agricultural sector. Their model incorporates inter- and intra-state productivity differences in a disequilibrium framework.

As mentioned above, most of newly constructed models are rather small, based on the VAR methodology. For instance Mallick (2004) has constructed a MEM using the data from 1950-1995 to examine the factors contributing to India's trade and inflation in an effort to address the effects of a reform policy package in an open economy context. In his opinion the use of non-stationary data in previous models has been a source of

misspecification. Although this model carefully handles issues associated with time series properties of the data, there are only five long-run and five short-run equations explaining the demand for real balances, the price level, export demand, export supply and imports. Mallick has estimated his behavioural stochastic equations by a fully modified Phillips-Hansen method to obtain the cointegrating vectors and the short-run dynamic model. In one of his simulation scenarios he concludes that the devaluation worsens trade balance and as such devaluation is not a good option in response to a negative trade shock but the reduction in domestic credit reflecting demand contraction leads to an improvement in the trade balance. More recently Kannapiran (2003) has specified and estimated a MEM using the IS-LM within a Mundell-Fleming framework for a small open developing economy (*i.e.* Papua New Guinea). Quarterly time-series data for the period 1979-95 are used to estimate only seven stochastic behavioural equations by the 2SLS method. Another example is a seven-variable VAR model constructed by Shan (2002) to examine Income Disparity in China using annual data for the period 1955-1998.

New generation of MEMs should also incorporate the important effects of human capital, trade openness and demographic factors on GDP growth. Guisan and Exposito (2001) thoroughly examined economic growth among a large number of countries in Asia and Africa during the period 1951-99. Their empirical results clearly indicate that policies aimed at expanding human capital and trade openness will improve economic growth. In another study, Guisan (2004) uses annual time series data for the period 1960-2002 for a number of countries including China, India and Japan and finds that increases in both human and physical capital as well as a higher degree of trade openness contribute to higher GDP growth. In fact his cross-country econometric results indicate that a higher degree of trade openness not only increases foreign demand and hence GDP but also it positively relates foreign trade with supply side factors leading to an expansion of industry, building and services (Guisan, 2004 and 2003). The effect on the supply side exhibits itself through “the availability in international markets of raw materials and intermediate inputs which are scarce in the domestic market” (Guisan, 2004, p.129). For example, the lack of infrastructures and funds has imposed serious restrictions on the supply side of many Asian countries and hence their economic growth including China and India. Love and Chandra (2004) use various types of cointegration techniques and the data for the period 1950-1992, in estimating their cointegrating vector and they find that trade openness has a long-run relationship with higher real per capita income growth in India. Therefore it is important to incorporate these aspects into MEMs for developing economies.

4. Concluding Remarks

This paper briefly reviews the history of macroeconometric modelling in developing countries. It seems that this field has contributed to the expanding knowledge of both economists and econometricians during the last six decades despite the fact that from the early 1970s, several issues invalidated the use of MEMs. These issues were: theoretical contrasts with rational expectations theory, structural instability, the arbitrary division of endogenous-exogenous variables of the model, and the possible existence of the problem

of unit roots (spurious regressions) and insufficient amount of econometric "know-how". Macroeconometric modelling in developing countries has been subject to criticisms on a greater scale because of the presence of an additional adverse factor of data unreliability. Apart from data problems which are inevitable, however, there are some specific modifications which should be implemented in constructing a MEM for each individual developing country to capture its specific structural peculiarities.

Nevertheless, macroeconometric modelling can still be a unique tool, especially for policy formulations provided that a wide variety of investigations, particularly in relation to model selection, diagnostic tests and time series properties of the data, are undertaken. With the advancement of econometric "know-how", the disparity of opinions between advocates and critics of macroeconometric modelling appears to be narrowing. Granger and Jeon (2003, p.9) argue "that the experience and outlook of the time series econometricians could be helpful in devising and interpreting experiments that potentially would improve the large models without completely removing their maintained sources of strength". However, this may take sometime, as Mankiw (1988, p.438) asserted in another context, "just as Copernicus did not see his vision fully realised in his life time, we should not expect these recent developments to yield high returns in the very near future".

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