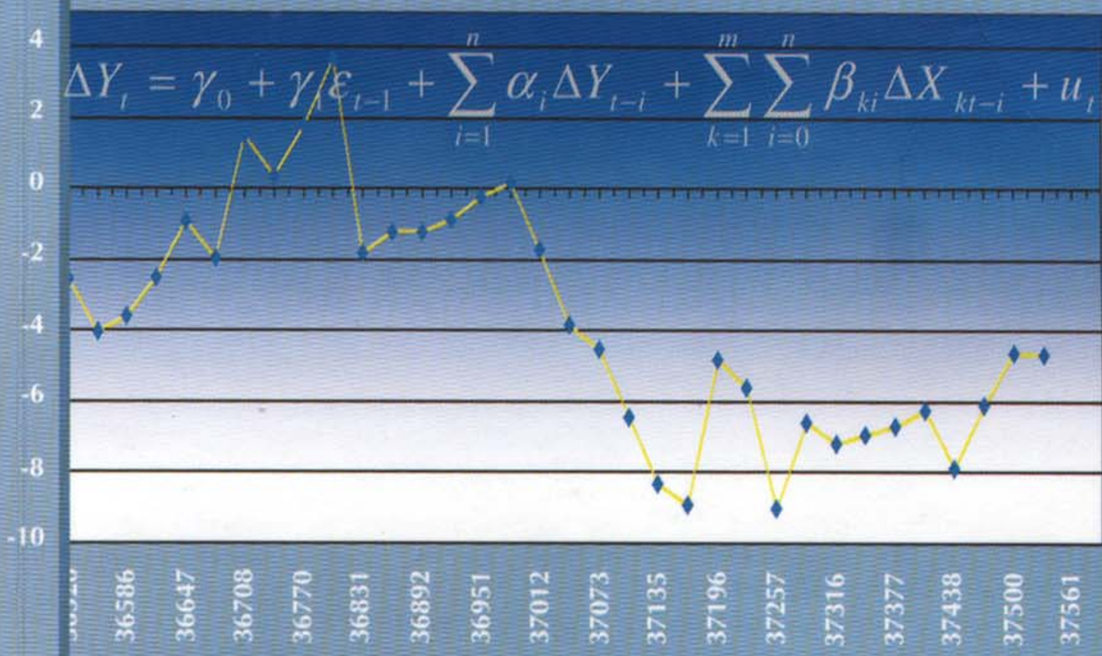
A Perspective on Macroeconomic and Economy-wide Quantitative Models of the Philippines: 1990-2002

Josef T. Yap



Philippine Institute for Development Studies
Surian sa mga Pag-aaral Pangkaunlaran ng Pilipinas

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Foreword

The Philippine Institute for Development Studies (PIDS) celebrated its silver founding anniversary in 2002. In this connection, various activities were held to highlight the contribution and significance of policy research in governance as well as to commemorate more than two decades of providing competent research.

One of these activities is the Perspective Paper Symposium Series where the PIDS research fellows presented a perspective of the development and evolution of issues and concerns over the past 25 years in their respective fields of specialization such as infrastructure, banking and finance, science and technology, human resources development and labor markets, competition policy, poverty analysis and housing development. The 11 papers covered most of the themes in the PIDS research agenda and presented reviews of specific policy issues from where policy debates can proceed with greater focus.

Such outputs, however, are best disseminated in book formats so as to widen the reach of the excellent observations, analyses and recommendations put forward by the Institute's inhouse pool of researchers. Thus, the Institute presents 11 commendable titles under the *Perspective Paper Series* as its contribution to Philippine policy research.

It is with confident expectation that this *Series* will provide the essential answers to the concerns and gaps in various policy issues which the Institute has been trying to address in the last 25 years.

This paper surveys the development of macroeconometric and CGE models in the Philippines during the period 1990-2002, primarily in terms of their structure and applications. Many of the recent developments in macroeconometric modeling have been incorporated in Philippine models. However, Philippine CGE models have hardly progressed beyond the standard neoclassical framework. Over time, there has been convergence in these two types of quantitative models: CGE models have increasingly used econometric estimates obtained from time-series data while macroeconometric models have been applied to monitor social outcomes like poverty and income distribution. These quantitative tools have become an integral part of policy analysis in the Philippines.

MARIO B. LAMBERTE, Ph.D.
President, PIDS

Abstract

Criticism against large-scale macroeconometric models built in the tradition of the Cowles Commission approach began to mount in the late 1960s. These misgivings were subsequently reflected in the Lucas critique, Sims critique, and disenchantment with the model's Keynesian foundations. In response, macroeconometric modeling progressed in two parallel ways: one, the improvement of the structure of the traditional models, particularly in terms of specifying the supply side and forward-looking expectations; and two, strengthening or development of alternative techniques, to wit, the London School of Economics (LSE) approach aided by the advent of cointegration analysis, vector autoregressive (VAR) systems, and dynamic stochastic general equilibrium (DSGE) models. The emergence of computable general equilibrium models can also be considered a response to the dissatisfaction with macroeconometric models. Computable general equilibrium models (CGE) models are based on a well-specified theoretical framework built on optimizing behavior of economic agents. They readily allow the analysis of the impact of policy changes on resource allocation and income distribution.

This paper surveys the development of macroeconometric and CGE models in the Philippines during the period 1990-2002, primarily in terms of their structure and applications. Many of the recent developments in macroeconometric modeling have been incorporated in Philippine models. However, Philippine CGE models have hardly progressed beyond the standard neoclassical framework. Over time, there has been convergence in these two types of quantitative models: CGE models have increasingly used econometric estimates obtained from time-series data while macroeconometric models have been applied to monitor social outcomes like poverty and income distribution. These quantitative tools have become an integral part of policy analysis in the Philippines.

1
Introduction

Quantitative models have become an essential tool for economic policymakers. The limitations of analytical models, particularly in assessing the general equilibrium effects of development policy, have increased the usefulness of what are called "stylized" and "applied" models. These models have been used to analyze issues like long-term growth and structural change, investment allocation, income distribution, trade policy, and the impact of structural adjustment and stabilization policies.

This paper reviews work in the areas of macroeconomic and economy-wide quantitative models in the Philippines. The term *macroeconomic models* has sometimes been used to denote both macroeconometric models (MEMs) and computable general equilibrium (CGE) models. However, macroeconometric models need not necessarily be economy-wide in nature (e.g., VAR systems with only a few equations) and most CGE models explicitly specify household behavior, breaching the boundary of macroeconomics. Hence, a distinction must be made between macroeconomic models—some of which can be economy-wide in nature, e.g., largescale MEMs—and economy-wide models—some of which are based on microfoundations.[1]

The period 1990-2002 is selected to avoid any duplication of comprehensive reviews written by Velasco (1980) and Bautista (1988). The former focuses on macroeconometric models while the latter includes the development of CGE modeling in the Philippines at its incipient stage. A natural tract for this review would be to discuss macroeconometric and CGE models separately.

Another reason for limiting the time frame is the proliferation of applied models in the Philippines, particularly those employing the CGE methodology. Unfortunately, even with this constraint in coverage, this survey cannot claim to be exhaustive, especially with regard to studies completed abroad.

[1]Linear programming models and those based on input-output tables are also economy-wide in nature, but these are not considered in this survey. Reduced form single-equation macroeconometric models are also excluded except for the model used by the BSP for inflation targeting.

The perspective paper begins with macroeconometric models, examining the criticisms against them, the development of techniques to overcome the weaknesses, and how Philippine models have fared vis-à-vis these advances. Section 2 then shifts to CGE models where the emphasis is more on the underlying theoretical structure. The third section deals with applications of macroeconomic and economy-wide models in studying the link between macroeconomic policy and social outcomes, namely, poverty and income distribution, health and nutrition, education, and the environment. The microeconomic impacts of macroeconomic adjustment policies Micro Impacts of Macroeconomic Adjustment Policies (MIMAP) project is in the forefront of these efforts and a separate section is devoted to models developed under its umbrella. The last section discusses some modeling issues that have to be resolved and attempts to contrive the characteristics of an ideal model.

2
Macroeconometric Models

The discussion on MEMs begins with the criticisms leveled against largescale macroeconometric models that were built using the Cowles Commission approach, which evolved primarily from the work of Jan Tinbergen and Lawrence Klein. This is followed by a description of the various responses to the critique: modifications to the traditional MEMs, the LSE approach, the vector autoregressive (VAR) models, and the calibration approach associated with real business-cycle theories. This section provides the theoretical background to MEMs, which allows a more comprehensive evaluation of the current state of applied macroeconometrics in the Philippines.

MEMs developed to prior to 1990 are mentioned briefly to provide a context for the models that are reviewed. This is followed by an individual discussion of selected models developed in the past dozen or so years. Emphasis is placed on the structure and estimation technique—to what extent it has addressed the various shortcomings of the Cowles Commission approach—and the applications of the model. A comparison of selected models is presented in Appendix 1.

Cowles Commission approach and critique

In its early stages, applied macroeconometrics was associated mainly with largescale macroeconometric modeling or the "system-of-equations" approach. This was synthesized in the Cowles Commission approach to model building, which consisted of identification and estimation of systems of stochastic difference equations designed to approximate the postulated decision rules of Keynesian macroeconomic theory (Diebold 1998).

Estimation in the Cowles Commission approach largely emphasized overcoming the problem of simultaneity. But once the models were estimated, the focus shifted to the main objective of these models, which was policy evaluation. This underscored the Keynesian view that the economy could be fine-tuned. Another notable application of large-scale MEMs was conditional forecasting—forecasts based on specified values of exogenous variables.

By the late 1960s and early 1970s, criticisms against the Cowles Commission approach began to mount. These could be classified as theoretical—the criticisms directed at its Keynesian foundations—and statistical—the criticisms that focused on the questionable identification process of largescale MEMs and their poor empirical track record in the 1970s. Many of the criticisms are well known and have been documented extensively. A succinct account is provided by Diebold (1998):

> . . . First, economists became dissatisfied with the lack of foundations for the disequilibrium nature of Keynesian models. A new and still ongoing research program began, which sought microfoundations for Keynesian macroeconomic theory, particularly for the central tenets of sticky wages and prices . . . Second, just as macroeconomists became increasingly disenchanted with the ad hoc treatment of sticky prices in traditional models, they became similarly disenchanted with ad hoc treatment of expectations. . . . Third, and most generally, economists became dissatisfied not only with certain parts of the Keynesian macro-econometric program, such as the assumptions about price behavior and expectations formation, but rather with the overall modeling approach embodied in the program . . . it concentrated on the estimation of parameters of equation systems representing ad hoc postulated decision rules ("consumption functions," "investment functions," and so on) as opposed to more fundamental parameters of tastes and technology . . . Finally, if the cracks in the foundation of Keynesian structural forecasting began as intellectual dissatisfaction, they were widened by the economic facts of the 1970s; in particular, the simultaneous presence of high inflation and unemployment, which naturally led economists to question the alleged inflation/unemployment trade-off embedded in the Keynesian system of equations. In addition, a series of studies published in the early 1970s revealed that simple statistical extrapolations, making no assumptions at all about economic structure, often forecasted macroeconomic activity just as well as largescale Keynesian macroeconomic models.

Another source of skepticism with macroeconometric models was the increased attention paid to the treatment of nonstationarity in macroeconomic variables, which gave rise to the possibility of spurious regressions.

The third part of Diebold's summary relates to the famous Lucas critique, which argues that analysis based on decision rules is not suitable for producing conditional forecasts, because the parameters of decision rules will generally change when the policy regime changes. The main reason why parameters will change is that the model does not take expectations into account explicitly and, therefore, the identified parameters within the Cowles Commission approach become a mixture of "deep parameters," describing preferences and technology in the economy, and expectational parameters which, by their nature, are not stable across different policy regimes.

Meanwhile, the poor performance of largescale MEMs was also attributed to problems in identification and specification. One consideration was that the specified structure was too restrictive, omitting relevant variables, including the dynamics of the included variables. A related aspect was that the restrictions applied, which were necessary in the course of making the model identified, delivered a structure which was deemed 'incredible.' In particular, the Sims critique pointed out that many variables were taken to be exogenous with respect to the system by default rather than as a result of solid economic or statistical arguments.

The following structural model, which deals with the monetary transmission mechanism, elucidates some of these points:[2]

$$A\begin{bmatrix} Y_t \\ M_t \end{bmatrix} = C(L)\begin{bmatrix} Y_{t-1} \\ M_{t-1} \end{bmatrix} + B\begin{bmatrix} \upsilon_t^Y \\ \upsilon_t^M \end{bmatrix} \quad (1)$$

The variables of interest are divided into two subsets: **Y**, which represents the vector of macroeconomic variables of interest and **M**, the vector of monetary variables determined by the interaction between the monetary authority and the economy. **C(L)** is a matrix finite-order lag polynomial and

$$\upsilon = \begin{bmatrix} \upsilon_t^Y \\ \upsilon_t^M \end{bmatrix}$$

is a vector of structural disturbances to the nonmonetary and monetary variables. Nonzero offdiagonal elements of the matrix **B** allow some shocks to affect directly more than one endogenous variable in the system.

The Cowles Commission approach sought to estimate the model and at the same time recover the elements of the matrices, particularly **A**. The latter defines the problem of identification. In traditional MEMs, identification was achieved mainly by treating some variables as exogenous. In this example, a subset of the **M** variables are taken to be policy variables, which are directly and fully controlled by the monetary authority. If money supply is assumed to be exogenous, the high correlations between money and economic activity will be interpreted as causal relation running from money to economic activity. However, in reality the level of money supply may result from higher demand resulting from greater economic activity.

Identification in the traditional approach was also aided by treating lagged dependent variables as exogenous and arbitrarily setting many of the elements of the C(L) matrix to zero. However, since the maximum lag length of an equation had to be estimated—it is an empirical issue—then lagged dependent variables could not be used in identification. Moreover, setting elements of C(L) to zero without any empirical justification was considered premature on the part of the model builder.

Recent developments in largescale macroeconometric modeling

The response to the critique took a two-way track. One was the strengthening or development of alternative approaches to macroeconometric modeling,

[2]This is obtained from Chapter 3 of Favero (2001).

which is discussed in the next section. The second was the modification of the traditional approach to constructing largescale MEMs.

The major efforts in both sets of responses can be classified in three areas. One is the greater use of economic theory in the specification of large-scale models, particularly the microfoundations of the underlying relationships. Second, in relation to the greater emphasis on theory, and under the influence of cointegration analysis, more focus was given to long-run relationships. The latter also addressed the issue of 'incredible' restrictions involving short-run dynamics.

And third, in response to the Lucas critique, a significant amount of effort was exerted to incorporate rational expectations, or model-consistent expectations, into large-scale MEMs. These developments have led new-generation MEMs to share a number of important features in terms of the three basic building blocks: equilibrium conditions, expectations formation, and dynamic adjustments (Garrat et al. 2000).

Greater attention on theory and the long-run invariably resulted in greater interest in the supply side of the model, and vice-versa. One reason is that the supply side of a macroeconometric model determines its long-run properties (Wallis 1995, 2000). On the other hand, a well specified supply side requires a quite sophisticated theory to allow the demand and supply sides to relate to each other in a reasonable way (Hall 1995).

A direct response to the Lucas critique was to specify the formation of expectations separate from the model of economic behavior given expectations. The practical solution of a model for the endogenous variable values over a forecast period then required an internally consistent forward-looking solution sequence to be calculated, in which each period's future expectations variables coincide with the model's forecast for the future period. With this implementation, the approach was more accurately and perhaps less controversially termed "model-consistent" expectations.[3]

Other major methodologies

Cointegration analysis and the LSE approach

The name evolved because its main proponents have been individuals associated with the London School of Economics, with the founder acknowledged to be Denis Sargan. The LSE approach explained the failure of the Cowles Commission methodology by attributing it to the lack of attention for the statistical model underlying the particular econometric structure (Favero 2001). In other words, the statistical congruence of the specification is considered by the LSE approach to be a much higher priority than the choice of the most appropriate estimator.

The LSE research strategy begins from the specification of a general statistical model or the data-generating process. Econometric modeling then consists of simplifying this very general formulation by imposing a set of

[3]Quoted from Wallis (2000)

restrictions. The traditional logic of the Cowles Commission, according to which the reduced form is derived given the structural model, is reversed within the LSE approach (Favero 2001).

Consider the following data generating process for Y_t:

$$Y_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{k=1}^{m}\sum_{i=0}^{n} \beta_{ki} X_{kt-i} + u_t \qquad (2)$$

where u_t is a white noise disturbance. This can be viewed as one of the equations obtained from the structural model in Equation 1. The choice of the variables is largely based on economic theory. After estimating Equation 2, the next step is to sequentially impose economically meaningful restrictions on the maintained hypothesis, each restriction being tested for significance against the slightly less restricted specification, which precedes it in the sequence (Cuthbertson et al. 1992). By applying this procedure to other behavioral equations, a multi-equation macroeconometric model can be built. Other steps would include testing for exogeneity and assessing the validity of over-identifying restrictions.

If m = n = 1, we obtain the simplest form of the model depicted in Equation 2:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \beta_0 X_t + \beta_1 X_{t-1} + u_t \qquad (3)$$

A useful reparameterization of Equation 3 introduces an error-correction mechanism (ECM):

$$\Delta Y_t = \alpha_0 + \beta_0 \Delta X_t - (1-\alpha_1)(Y_{t-1} - X_{t-1}) + \gamma X_{t-1} + u_t \qquad (4)$$

where $\gamma = \alpha_1 + \beta_0 + \beta_1 - 1$.[4] Proponents of the LSE tradition maintain that Equation 4 is intuitively more appealing than Equation 3. The ECM specification can be justified theoretically within a quadratic costs of adjustment framework and it also captures the idea that agents alter their behavior according to indications that they are out of equilibrium.

The development of cointegration analysis then neatly condensed the LSE approach to constructing a macroeconometric model. The Granger representation theorem states that if a set of variables is cointegrated of order 1,1 [i.e. CI(1,1)] then there exists a valid error-correction representation of

[4]It is also called an error-correction model (ECM). Note that an ECM can be specified with any values of n and m.

the data.[5] The practical implications of this for dynamic modeling were profound: for an error-correction model to be immune from the spurious regression problem, it must contain a set of levels terms which cointegrate to give a stationary error term (Cuthbertson et al. 1992).

Based on this discussion, the first step in parameterizing Equation 2 would naturally be to estimate a cointegrating relation, of which there are many alternative methodologies, including ordinary least squares (OLS). This relation would represent the equilibrium or long-run relationship among the variables. The residuals can then be used in estimating the ECM. This is essentially the Engle-Granger two-step procedure, which has been applied widely. The process would be repeated for all equations in the MEM. It should be noted, however, that neither cointegration analysis nor the ECM specification is monopolized by the LSE approach.

A variant of the LSE methodology deals directly with systems of behavioral equations, as in Equation 1, and accounts for the possibility of there being more than one cointegrating relationship among a set of three or more variables. The procedure is to specify an unrestricted VAR system and use the Johansen procedure to estimate all the possible cointegrating relationships. Tests can then be applied to determine appropriate cointegrating relations, whether they are based on theory or the direct empirical results. The appropriate cointegrating relation is then used to simplify the VAR system into a vector error correction model (VECM).

A similar procedure was advocated by Garratt et al. (2000) in what they termed the "Structural Cointegrating VAR Approach." Their methodology, however, differs from the standard approach, which starts with an unrestricted VAR and then attempts to impose restrictions on the cointegrating relations, without a clear a priori view of the economy's structural relations. The methodology of Garrat et al. begins with an explicit statement of the long-run relationships obtained from macroeconomic theory. The advantage of the structural cointegrating VAR approach is that the equilibrium relationship is firmly rooted in optimizing behavior.

However, the VAR approach—whether using unrestricted estimates or that of Garrat et al.—cannot be readily applied to a large-scale MEM. As a matter of fact, the structural cointegrating VAR model is highly restrictive and it can deal with at most 8-10 variables simultaneously (Garrat et al. 2000).

The resulting macroeconometric model can then be used for policy analysis and forecasting in the same spirit as the Cowles Commission approach. It must be emphasized that the LSE approach considers econometric policy evaluation an interesting and feasible exercise.

[5]Cointegration may be formally defined thus: The components of the vector X_t are said to be cointegrated of order d, b [denoted $X_t \sim CI(d, b)$] if: a) all components of X_t are I(d); and b) there exists a vector such that $Z_t = \;' X_t \sim I(d-b)$, b>0. I(d) indicates that the process becomes stationary after differencing d times.

Vector autoregressive (VAR) models

Other alternatives to the traditional MEMs are VAR models introduced by Christopher Sims. These are just a multiple time-series generalization of the AR model. Similar to the LSE approach, the VAR methodology considered the identifying restrictions employed by traditional modelers as unrealistic.

However, unlike the LSE approach, the VAR methodology questioned the potential of traditional MEMs for policy simulation and evaluation. A case in point is that the LSE methodology recognized the problem of the invalid exogeneity assumption for some of the monetary variables **M** in the model in Equation 1. Nevertheless, the model could still used for policy simulation and econometric policy evaluation, whenever the appropriate concept of exogeneity was satisfied by the adopted specification.

The VAR approach fully recognized the Lucas critique and acknowledged that policies should be evaluated within the framework of general equilibrium models of the business cycle. The primary role of VAR models has been to provide evidence on the stylized facts that should be included in a theoretical model and to decide between two competing general equilibrium models (Favero 2001).

Typically what is estimated is the reduced form of Equation 1, as follows:

$$\left[\begin{matrix} Y_t \\ M_t \end{matrix}\right] = D(L)\left[\begin{matrix} Y_{t-1} \\ M_{t-1} \end{matrix}\right] + \left[\begin{matrix} u_t^Y \\ u_t^M \end{matrix}\right] \qquad (5)$$

VAR models would then focus on shocks, which are simulated through the disturbances u_t. First, the nature of the shocks are defined, and then the response of the system to the shocks is described by analyzing impulse responses, forecasting error variance decomposition, and historical decomposition.

The identification problems related to VAR models and other nuances of this approach are beyond the scope of this paper. However, it should be noted that when the problem of nonstationary arises, the appropriate methodology would be to transform the VAR into a VECM representation using underlying cointegrating relations among the variables. Hence there is a convergence between VAR models, cointegration analysis, and the LSE approach in terms of estimation methodology.

Dynamic stochastic general equilibrium models

DSGE is another term for models of the real business cycle that employ the calibration approach. The underlying framework is intertemporally optimized models applied to decision problems of households and firms. First-order conditions yield equations that are expressed in terms of 'deep' structural parameters, which are the parameters that enter the preferences, production technologies and the probability distributions of tastes and technology shocks.

To illustrate the basic concepts, we use the simplest version of the inflation-targeting problem.[6] The central bank faces the following intertemporal optimization problem:

$$\min \mathrm{E}_t \sum_{i=0}^{\infty} \delta^i L_{t+i} \qquad (6)$$

where:

$$L = \frac{1}{2}\left[(\pi_t - \pi^*)^2 + \lambda \cdot x_t^2\right] \qquad (7)$$

In this set-up, E_t denotes expectations conditional upon the information set available at time t, δ is the relevant discount factor, L is the loss function of the central bank, π_t is inflation at time t, π^* is the target level of inflation, x represents deviations of output from its natural level, and λ is a parameter which determines the degree of flexibility in inflation targeting. When $\lambda=0$, the central bank is defined as a strict inflation targeter. Since the monetary instrument is the policy rate, i_t, the structure of the economy must be described to obtain an explicit form of the policy rule. We consider the following specification for aggregate supply and demand in a closed economy:

$$x_{t+1} = \beta_x x_t - \beta_r (i_t - \mathrm{E}_t \pi_{t+1} - \bar{r}) + u_{t+1}^d \qquad (8)$$

$$\pi_{t+1} = \pi_t + \alpha_x x_t + u_{t+1}^s$$

The first order conditions for optimality may be written as:

$$\frac{dL}{di_t} = (\mathrm{E}_t \pi_{t+1} - \pi^*) = -\frac{\lambda}{\delta \cdot \alpha_x \cdot k} \mathrm{E}_t x_{t+1} \qquad (9)$$

$$k = 1 + \frac{\delta \alpha_x k}{\lambda + \delta \alpha_x^2 k} \cdot$$

The equations in (9) are orthogonality conditions involving all the deep parameters describing the preferences of the central banker π^*, δ, λ, and only one parameter coming from the structure of the economy, α_x. By combining (8) and (7) and substituting into (9), we obtain:

$$i_t = \bar{r} + \pi^* + \left(\frac{1 + \alpha_x \beta_r}{\alpha_x \beta_r}\right)(\mathrm{E}_t \pi_{t+1} - \pi^*) + \frac{\beta_x}{\beta_r} x_t + \frac{\lambda}{\delta \alpha_x k} \frac{1}{\alpha_x \beta_r} \mathrm{E}_t x_{t+1} \qquad (10)$$

[6]The inflation-targeting example and the accompanying discussion are lifted from Chapter 3 of Favero (2001), pages 99-101. One purpose of presenting this example is to clarify the nature of deep parameters.

This is the interest rate rule, the parameters of which are convolutions of the parameters describing the central bank's preferences and of those describing the structure of the economy. Thus, it is impossible to assess from the direct estimation of the rule whether the responses of central banks to output and inflation are consistent with the parameters describing the impact of the policy instrument on these variables. However, it can be observed that the deep parameters are much more easily identifiable from (9).

The identification and estimation strategy, naturally consistent with the intertemporal optimization approach, is then to estimate first the aggregate demand and supply functions to arrive at an estimate of α_x and the βs. The Euler equations derived from (9) can then be used to pin down the deep parameters of interest. This step is achieved by applying an estimation method directly on orthogonality conditions, which is the generalized method of moments. Numerical values to the remaining parameters in the model are then attributed, not necessarily by estimation. Calibration can be applied. Finally, the models are simulated and evaluated by comparing actual data with simulated data.

Overview of MEMs prior to 1990

The survey of Velasco (1980) was part of the groundwork for the Philippine Institute for Development Studies-National Economic Development Authority (PIDS-NEDA) macroeconometric modeling project. The concluding remarks in his study identified aspects that could be incorporated in future models. In a nutshell, Velasco recommended that the strengths of the different models existing at that time be combined in one model. However, probably because of the timing of the survey, none of the fundamental weaknesses of the Cowles Commission approach was mentioned. Instead, Velasco focused on the structure of the existing models.

One aspect was the explicit consideration of the trade deficit and investment-savings gap and the determination of the required capital flows defined by these imbalances. The sustainability of servicing the foreign debt was a related issue. Because of the importance of modeling the trade deficit—and consequently the current account deficit—it was recommended that equations for exports and imports be properly specified and estimated. The proposal also cited the need for a more disaggregated trade sector and a clear link between the trade sector and production sector. In particular, Velasco emphasized the role of imports of fuel.

The link between the financial and real sectors also figured prominently in Velasco's review. Several models, among them the early Central Bank models, were built to simulate the transmission channels of monetary policy. However, they did not have an extensive description of the real sector.

The linkages were primarily through investment. Meanwhile, despite having a monetary submodel, the Encarnación model's only link between the monetary and real sectors was between money supply and the price level.

Another area considered worth exploring was a fiscal planning model that would serve as a basis for revenue forecasting and as a guide for budget allocation. The model would also help in managing the national debt by determining a sustainable level of debt-servicing.

The survey of Bautista (1988) also analyzed the structure of several MEMs in the Philippines. However, more emphasis was placed on the shortcomings of MEMs, with the view of showing how CGE models compensated for these. Most, if not all, of the drawbacks of traditional MEMs discussed earlier were acknowledged by Bautista. Hence, many of the recommendations mentioned in his concluding section mirror the developments outlined in the section on other major methodologies on page 6. These include a more robust specification of the dynamic behavior of MEMs and a more realistic treatment of expectations.

MEMs in the Philippines

PIDS-NEDA annual model

The PIDS-NEDA Annual Macroeconometric model has several versions, the last of which is that of Reyes and Yap (1993). One publication that presents a model incorporating the important features of the different versions is Mariano and Constantino (1994). The main objective of the PIDS-NEDA model was to provide a coordinated framework for the formulation of the medium-term development plan of the Philippines. In its early stages—which coincided with the first few years of the Aquino administration—the model was used extensively in the negotiations involving the country's external debt. Estimates of a sustainable level of debt payments were calculated, which were used to argue for more meaningful debt restructuring. The model was also used to evaluate the impact of stabilization policies on the Philippine economy.

The later versions of the PIDS-NEDA model are essentially structuralist in nature although the expenditure sector is specified along the lines of a Keynesian income-expenditure model. It is structuralist in the sense that it takes into account supply bottlenecks as affecting certain sectors of the economy and allows for less than full employment equilibrium. By giving adequate attention to the supply side, the model recognizes important characteristics of developing economies.

The core of the model is the real sector, which determines domestic output, its production and expenditure components, prices, employment, and wages. The interaction of the production and expenditure sectors determines gross domestic product (GDP). The different production sectors have both a supply and demand equation, which are specified in three ways: with a fixprice mechanism, a flexprice mechanism, or a flexprice/flexquantity mechanism. The fixprice sector is assumed to have an adjusting output level, with prices set by relatively stable mark-ups over variable cost. This is most applicable to the industrial sector, which is often characterized by an oligopolistic structure. The service sector follows the same fixprice specification while the various sectors in agriculture are specified in either of the two other ways. Meanwhile, the expenditure side of the real sector is disaggregated into traditional components in the national income accounts. These are then linked to the demand equations of the production sector.

GDP is built up from the production side and gross national product (GNP) is then calculated with the addition of net factor income from abroad. This is reconciled with the expenditure side by taking the statistical discrepancy as a residual component of GNP from the expenditure side. Two measures were adopted to ensure that the statistical discrepancy did not absorb a disproportionate part of any shocks to the system. One, the linkage between the production and expenditure side was carefully specified. As mentioned earlier, individual aggregate expenditure categories—not aggregate GDP—appear in the demand side of the production function. Feedback from production to the expenditure sector is reflected in the use of domestic output as an activity variable in the equations for the expenditure components.

The second measure was applied in simulation exercises. Adjustments were made to maintain the same level of the statistical discrepancy—either in absolute terms or as a ratio to GDP—in the baseline simulations and the "shock" runs.

The PIDS-NEDA model has separate fiscal, financial, and trade blocks. Government expenditure is normally treated as exogenous. The financial sector determines money supply and interest rate and the linkages with the real sector are better specified than earlier MEMs. Meanwhile, the trade sector has varying degrees of disaggregation but ultimately determines the trade balance which feeds into the current account balance and overall balance-of-payments position. The BOP account feeds into the money supply process via net foreign assets of the central bank.

The PIDS-NEDA model is considered a vast improvement over earlier MEMs. The major upgrades are the explicit treatment of certain unique features of the Philippine economy and the strong linkages among the various sectors. However, it is still specified along the lines of the Tinbergen-Klein tradition, whereupon it is subject to the critique presented earlier.

Soon after its completion, the Reyes-Yap version of the PIDS-NEDA model was applied to address the problem of the fiscal constraint (Reyes and Yap 1993b). Because of the sharp decline in public infrastructure spending and maintenance and operating expenditures between 1985 and 1991, the economy did not sustain its recovery from the 1983 BOP crisis. Hence, alternative ways to finance an increase in public expenditure were studied. The simulation exercises, which were conducted over a five-year period, yielded the following ranking of the various options considered:

1. Increased revenue through better tax administration;
2. Increased revenue through an increase in the tax rate;
3. External borrowing;
4. Reallocation of expenditure from consumption to capital outlays;
5. Monetization of additional public expenditure; and
6. Domestic borrowing.

The ranking was based on the behavior of output, with the assumption that the macroeconomic imbalances were sustainable.

A modified version of the same model was used to determine whether analytical conditions obtained from a three-gap model were relevant empirically (Yap 1997). The objective was to determine the macroeconomic impact of a reduction in the tariff level, which largely depended on the response of the surplus in the government's primary account. If it fell, the fiscal and savings constraints would become tighter, leading to a contraction in investment and output. The behavior of the government's primary surplus after a reduction in the tariff level was largely an empirical issue that depended on the price and income elasticities of the demand for imports.

To study this problem, an aggregate tariff variable was estimated and incorporated in the relevant equations, particularly in the import price equation. Using an aggregate tariff variable may be deemed unrealistic, since different sectors are subject to varying tariff levels. However since imports are not disaggregated, a one-good economy was implicitly assumed, justifying this specification.

Policy simulations indicated that the primary surplus of the government fell after a reduction in the tariff level implying that the latter would have contractionary effects on the economy. This result does not necessarily mean abandoning the policy of trade liberalization. Fewer distortions in the economy could improve efficiency and productivity, and this effect was not captured in the macroeconometric model. The more relevant policy consideration was that the fall in tariff revenue could have been offset by more effective tax administration. Unfortunately, the 1996 Comprehensive Tax Reform Program resulted in a diminution in excise taxes, which exacerbated the fiscal problems of the government.

NEDA quarterly macroeconometric model

The NEDA-QMM (1996 and 2000) represented a clean break from past approaches to modeling the Philippine economy. Under the guidance of Peter Pauly of the University of Toronto, a team from different government agencies estimated a large-scale MEM using quarterly data. Each government agency was responsible for a particular block of the model, e.g., the Bangko Sentral ng Pilipinas (BSP) specified and estimated the monetary block of the QMM.

The key feature of the QMM was its use of the Engle-Granger two-step procedure described earlier. Assuming again that the data generating process is specified as:

$$Y_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{k=1}^{m} \sum_{i=0}^{n} \beta_{ki} X_{kt-i} + u_t \qquad (2)$$

The first stage estimates the static part as follows:

$$Y_t = \alpha_0 + \sum_{k=1}^{m} \beta_k X_k + \varepsilon_t \qquad (11)$$

If a cointegrating relationship can be found, i.e., ε is stationary, then the second stage consists of estimating the following error correction model (ECM):

$$\Delta Y_t = \gamma_0 + \gamma_1 \varepsilon_{t-1} + \sum_{i=1}^{n} \alpha_i \Delta Y_{t-i} + \sum_{k=1}^{m} \sum_{i=0}^{n} \beta_{ki} \Delta X_{kt-i} + u_t \qquad (12)$$

In some cases only the first stage, oftentimes incorporating a lag structure, was estimated.

By applying this methodology, there would be a clear distinction between the short- and long-run behavior of the model. The long-run values should converge to the levels dictated by the cointegrating relationship. However, the latter is derived from empirical data and is not necessarily consistent with relationships obtained from optimizing models.

Another feature of the QMM was its extensive use of empirical tests to assure the robustness of the individual stochastic equations—normality, serial correlation, heteroscedasticity, and others—following the tradition of the LSE approach. Many of these tests were not available in earlier software packages, attesting to the great effort of the modeling team.

The structure of the QMM largely follows that of the annual model, with the core being the real sector. Private consumption is disaggregated into food and nonfood, but the relevance of this specification is limited, since value-added in agriculture is determined via a production function. The latter does not allow a meaningful link between food consumption and agricultural production. Meanwhile, the production sector, surprisingly, is not disaggregated into the different components of agriculture and industry. Moreover, value-added in industry and services is affected by GDP and not by specific expenditure components. This greatly weakens the feedback from the expenditure side to the production side, since GDP is built up from the production sector.

The NEDA-QMM incorporates a capacity utilization variable that is calculated as a ratio of actual GDP and a measure of potential GDP. This feeds into the equation for expected inflation, but not into the price levels and employment. Expected inflation is modeled by first estimating an inflation function. The latter is then inserted into the maroeconometric model after adjusting all variables forward by one period. Other explanatory variables in the expected inflation equation are import prices, money supply, and the implicit price index for agriculture.

Expected inflation is a determinant of the 91-day Treasury bill rate. It is also subtracted from certain interest rates to arrive at a measure of real interest rates. The real lending rate is an explanatory variable in the equations for investment spending.

In the simulation exercises, model-consistent expectations were not derived. In other words, the estimated inflation rate calculated from the growth of the consumer price index was not compared with the generated values of expected inflation. While there is no compelling reason to force them to be equal, at the very least the values should not deviate from each other in the entire simulation period. This aspect was not examined.

The model is quite large, which qualifies as both an advantage and disadvantage. On the one hand, the QMM can address many macroeconomic policies simultaneously and evaluate their consistency across many sectors. However, it would be difficult to generate timely forecasts using this model given its large information requirements.

The QMM is one of the models beings used by the National Planning and Policy Staff of NEDA.[7] One application is related to their role in the Development Budget Coordinating Committee, wherein various fiscal policy scenarios are assessed. The QMM is also used to evaluate the impact of changes in key macroeconomic variables like the wage rate—which usually serves as an input to discussions of wage bodies like the National Wages and Productivity Council—oil price and interest rate. The model also provides empirical support to policy recommendations made by NEDA to Congress.

Ateneo macroeconomic forecasting model

The AMFM is the newest member in the family of multi-equation macroeconometric models. It is a quarterly model comprised of 13 stochastic equations and 53 identities. This was developed by U-Primo E. Rodriguez and Roehlano M. Briones, and was largely based on the Murphy model of Australia.

The real sector of the model has both a production and expenditure sector. Unlike the NEDA models, output is determined from the expenditure side. The most interesting feature, though, is the production sector, which follows a two-stage process. The price level then adjusts to equate total expenditure with total production.

The first stage of the production process represents optimizing behavior of firms based on profit maximization. The values derived are considered to be equilibrium levels. The second stage is composed of a series of equations that depict the adjustment of economic variables to equilibrium. These are sometimes formulated as an ECM although the authors did not use this term in their paper.

The objective of the representative firm is to maximize profits, subject to given prices, capital stocks, and technology. Thus

$$\text{Max } \pi = px \cdot x + pnt \cdot y - w \cdot lt - pm \cdot m - pnt \cdot rr \cdot \bar{k}_{-1}$$

[7]NPPS-NEDA provided a brief dated August 27, 2002, describing their use of the QMM and the AMSM.

subject to $q = g(x,y) = f(lt, \bar{k}_{-1}, m)$

where *px* is the price of exports, *pm* is the price of imports, *pnt* is the price of the domestic good (net of indirect taxes), *w* is the wage rate, and *rr* is the real return to capital. Gross output *q* is produced using labor (*lt*), imports (*m*), and capital (*k*). The output is destined either for the domestic market (*y*) or export market (*x*). The AMFM assumes that $g(x,y) = (A_{CET} \cdot x^2 + y^2)^{1/2}$, a constant elasticity of transformation (CET) function, and $f(lt, \bar{k}_{-1}, m) = A_{CD} lt^{\beta_1} \cdot m^{\beta_2} \cdot k_{-1}^{1-\beta_1-\beta_2}$, a linearly homogenous Cobb-Douglas production function.

Given these assumptions, first-order conditions can be derived, which then yield a system of equations determining *qe, xe, me, lte, pnte* and λ. The latter is the Lagrange multiplier. The appended letter *e* denotes an equilibrium value, e.g., *me* is equilibrium imports. Actual values are calculated based on parameters obtained extraneously. For example, β_1 and β_2 are obtained by taking the average cost shares of labor and imports in gross output, respectively, from the fourth quarter of 1984 to the second quarter of 2001.

The equilibrium values then appear as determinants of actual values. For example, imports is estimated as

$$\Delta m = -18042.5 - .602 \cdot (m_{-1} - me_{-1}) + .408 \cdot \Delta me + \ldots..$$

In this approach the error correction mechanism is based on equilibrium values derived from a theoretical model. On the other hand, the Engle-Granger two-step procedure derives the equilibrium values from the estimated cointegrating relation. In other words, they are based on what the data yield. Unfortunately, the authors of the AMFM did not test whether the differences between the actual and equilibrium values, e.g., (*m – me*)—which is equivalent to e in Equation 11—are stationary. A nonstationary series would imply that either the theoretical model or the assumed functional forms or both are inappropriate descriptions of the Philippine economy.

The AMFM also specifies forward-looking inflationary expectations. Unlike the NEDA-QMM, expected inflation is a function of present and past values of inflation. This choice of specification would likely make it difficult to achieve convergence in the process of obtaining model consistent inflationary expectations. The authors, however, did not make the latter a criterion for convergence in their simulation exercises. Hence, the model is susceptible to the same problems as the NEDA-QMM.

Fixed investment is based on Tobin's q model and is the channel through which inflationary expectations influences the real economy. Fixed investment is positively related to the discrepancy between the average return to capital and the required return to capital. The latter is defined as the real interest rate plus the rate of depreciation. In turn, the real interest rate is the nominal interest rate deflated by inflationary expectations. All things remaining the same, higher inflationary expectations lead to an increase in the level of fixed investment.

The fiscal sector determines the government deficit. However, the latter does not feed into the real economy, particularly through interest rates, which are the normal channels. The model does distinguish between alternative ways to finance the deficit but the actual composition has no repercussions on the rest of the economy. The major reason is that money supply is exogenous. This is also the reason why the BOP has no transmission mechanism into the real economy.

The absence of a link between the fiscal deficit—and the manner by which it is financed—the BOP account, and the real sector limits the feedback mechanisms in the model. This would impair any policy evaluation results obtained from the model.

Models for inflation targeting

The Bangko Sentral ng Pilipinas (BSP) formally shifted to an inflation targeting regime in January 2002. Prior to this, monetary policy decisions relied for the most part on information on monetary aggregates. These served as operating targets under the monetary targeting framework employed then by BSP.

Several developments led to the decision to adopt inflation targeting. First, countries that adopted this framework have shown better performance in terms of lower and more stable inflation rates. Second, financial liberalization has limited the efficacy of monetary aggregates both as a lever of monetary policy and as an indicator of the monetary stance (Tuaño-Amador and Paraso 2002). Lastly, the more flexible exchange rate regime that followed the 1997 East Asian financial crisis is more conducive to an inflation targeting framework.

Under inflation targeting, the BSP becomes more forward-looking in its approach to monetary policy. Monetary decisions are based on the BSP's policy reaction function, which can be represented by Equation 10 above. The BSP would set its policy rates (specifically its overnight borrowing and lending rates) based on the assessment of future inflation—$E_t\pi_{t+1}$ in the equation—and output growth— x_t in the equation—relative to the desired path of these variables. Operationally, inflation targeting entails a careful review and analysis of past and current trends in indicator variables along with the forecasts of inflation.

The use of inflation forecasts is an essential feature of inflation targeting because of the lags between monetary actions and their ultimate impact on inflation. At present the BSP uses a single-equation monthly inflation-forecasting model in tandem with a small multiple equation model that was estimated with quarterly data. The BSP is also developing an annual macroeconometric model that captures the various transmission mechanisms of monetary policy.[8]

[8]The annual model was presented to the public for the first time at the Philippine Economic Society annual meeting on April 10, 2003. The development of the inflation forecasting models has been undertaken with the help of Professor Roberto S. Mariano of the University of Pennsylvania. The BSP economic research staff provided power point presentations (July 2001) on the single- and multiple-equation models, but actual estimates were withheld.

The single-equation monthly inflation-forecasting model is a successor of the original model developed by Mariano (1985). The equation was estimated using OLS, with the dependent variable being the consumer price index, CPI. The explanatory variables in the model are:

M4GDPN*	- ratio of M4 to nominal GDP
NWAGE*	- legislated nominal minimum wage, nonagriculture sector, Metro Manila
TBILL*	- 91-day Treasury bill rate
WOILPR*	- weighted average price of domestic petroleum products
MAPNPNOIL*	- 3-month moving average of price index for nonoil imports
NGBALCUM	- cumulative NG fiscal position
DCRISIS	- dummy variable for rice crisis in 1995
SQ4	- dummy variable for seasonal effect in Q4

Variables marked with '*' are those that appear in the original Mariano model. The equation was estimated in the form:

$$D(LCPI) = \alpha_0 + \alpha_1 D(LM4GDPN) + \alpha_2 D(LNWAGE) + \alpha_3 LTBILL + \alpha_4 D(LWOILPR) + \alpha_5 DCRISIS + \alpha_6 D(LMAPNONOIL) + \alpha_7 (NGBALCUM_{-2} - NGBALCUM_{-3}) + \alpha_8 SQ4$$

where 'D' indicates first difference and 'L' indicates logarithmic transformation.

The multiple equation model was estimated to ensure the consistency of the values of the variables used in forecasting. For example, changing GDP would have repercussions on M4 and TBILL. These relations are captured in the model. Accounting for inflationary expectations could be one area where both models could be improved.

At present, the BSP reaction function consists of formal meetings of the Monetary Board, which makes decisions based on economic trends. A more formal reaction function—which could aid in the decisionmaking process—could also be estimated based on the econometric models. What would be required is a transmission mechanism from the policy rates to the relevant variables. The BSP could also attempt to derive optimal values of λ, δ, and π^* based on historical data.

Other quantitative macroeconomic models

To help address the issue of balanced regional economic growth, a prototype econometric model was built for Region 7 (Danao 1991). A top-down approach was applied wherein the national model generated values of economic variables which were fed as exogenous inputs to the regional model. An attempt to build a full-blown regional model was constrained by the lack of intraregional trade data. Moreover, for the regional model to be relevant for policy analysis, a bottom-up approach was required. Because of the lack of data for certain variables at the regional level, it was difficult to reconcile the bottom-up approach with national aggregates.

Reyes and Yap (1993c) applied cointegration analysis to examine the relationship of money and prices during the period 1981-1992. The theoretical relationship centered on a concept of the long-run equilibrium of the price level or P^*. The latter is defined as the price level consistent with the current value of money supply M, the long-run equilibrium value of velocity V^*, and the current value of potential real GNP Q^*:

$$P^* = \frac{MV^*}{Q^*}$$

Linearizing this model with the use of logarithms, and utilizing the concept that P and P^* must be cointegrated, multivariate cointegration analysis was applied with the variables P, M, V^*, and Q^* using the Johansen procedure. The empirical results yielded only one significant cointegrating vector and tests indicated no causality between money and prices. This outcome was supported by results obtained from a standard Granger-Sims causality test. The authors observed that this result was consistent with the notion that the Central Bank of the Philippines at that time was influencing the exchange rate to control the inflation rate.

Meanwhile, the study of Gochoco (1993) applied the Engle-Granger two-step procedure to examine the relationship between various monetary aggregates and real income, the 91-day Treasury bill rate, and the nominal exchange rate. Her analysis was based on the notion that in selecting a particular monetary aggregate to target, not only must the latter be controllable by the BSP; it should also have a stable and predictable relationship with the variables of interest. The estimates show that only narrow money, M1, is cointegrated with real income, the 91-day Treasury bill rate, and the nominal exchange rate taken together. This result, along with other evidence, leads Gochoco to conclude that M1 is the best choice for a target variable.

Endriga (1993) employed VAR analysis to determine whether controlling the money stock or fixing the interest rate was the more effective policy in terms of higher and more stable output. Using monthly data for the period 1981-1991, the author showed that lagged interest rate variables do not appear significantly in the output equation. Meanwhile, the variance decomposition analysis indicated that money supply explained more of output variation compared to the interest rate variable. These findings were consistent and supported the conclusion that the money stock-targeting was superior. The results also supported the theoretical proposition that the investment demand function had been subject to greater instability than the money demand function.

Assessment

Macroeconomic modeling in the Philippines in the past 12 years has generally kept pace with theoretical developments abroad. However, there are gaps that remain.

The issue of incorporating more theory, the supply side, and long-run properties has been addressed in a variety of ways. The PIDS-NEDA Annual Model has a well-specified production sector with appropriate linkages with the expenditure sector. However, since it still follows the Cowles Commission methodology, it may be susceptible to the drawbacks of this approach. The NEDA-QMM attempts to overcome this problem by adopting the Engle-Granger two-step estimation technique. This approach, however, is not without potential pitfalls.

First, the standard errors produced by OLS when performing static cointegration regression—the first stage—are biased and so valid inference about the parameters of the cointegrating vector cannot be carried out in the usual way (Cuthbertson et al. 1992). Second, since the equations are estimated in the context of a large model, single equation estimation in the second stage—the dynamic part—is likely to yield inefficient estimates (Canova 1995). Third, there is a distinct possibility of more than one relevant cointegrating vector and the Engle-Granger procedure may simply yield a linear combination of these.

One solution is to adopt a multivariate framework for estimating cointegrating relations. However, as mentioned earlier, the drawback of this approach is that it can be applied optimally only when 8-10 variables are used. To get around this problem, one can estimate a core model and build satellite models around it (Garrat et al. 2000). Each satellite model would be constructed in the same manner. However, any feedback mechanism that arises because of common variables among the models should only flow in one direction, with the transmission process always beginning with the core model.

The AMFM is built along the same logic with the production sector being the centerpiece of the model. However, the same optimization behavior is not applied in constructing the other sectors and feedback mechanisms work in both directions. Moreover, as stated previously, the authors did not test whether the equilibrium values they estimated for key variables actually qualify as such.

Majority of the recent MEMs treat inflationary expectations explicitly (including the NEDA Annual Macro Social Model below). However, by estimating an equation for inflation and then incorporating this as forward-looking inflationary expectations by moving the variables one period ahead, the authors are implicitly assuming rational expectations. Hence when the inflationary expectations appear as explanatory variables, special estimation techniques—e.g., the Errors in Variables Method—must be applied. None of the models took this course.

VAR systems and DSGE models are also not without their problems. The former has been criticized as being atheoretical and overparameterized (Canova 1995). Meanwhile, estimates of "deep parameters" in DSGE models have oftentimes shown a degree of instability that is not acceptable (Favero 2001). The number of variables that can be accommodated in an intertermporal optimization framework is not large. This means that to build a relatively large DSGE model, several models must be combined. The theoretical soundness of the combined model is not clear.

While the recent MEMs have applied estimation techniques that are in principle more robust, empirical performance is another matter. An interesting study compared the tracking ability of the NEDA Annual Macro Social Model—which also used the Engle-Granger two-step procedure and was labeled an ECM model—with an updated version of the PIDS-NEDA model—labeled an OLS model (Reyes and Buenafe 2001). Goodness-of-fit was based on the mean absolute percentage errors derived from in-sample dynamic simulations. Out of 111 endogenous variables, the MAPE for the ECM model was less in 57 of the variables, which indicated that the ECM has no distinct advantage. However, the authors concluded that the Engle-Granger two-step procedure was more useful for variables exhibiting more volatility.

The complications associated with the proposed remedies and their apparent lack of a significant advantage in terms of tracking ability, make the Cowles Commission approach seem less problematic. The methodology could still be deemed appropriate so long as the magnitudes and direction changes obtained from simulation results are reasonable.[9] However, since computer software and hardware that are necessary to apply the different techniques are readily available, there is no compelling reason not to work with the more theoretically sound models.

[9]Recent examples are Bautista (2001) and Yap (2000). In the latter model, residuals of behavioral equations were tested for stationarity.

3

Computable General Equilibrium Models

CGE modeling can be viewed as an extension of the economy-wide, multisectoral analysis based on the Leontief input-output model (Bautista 1988). Work on CGE models began in the early 1970s. Two factors have contributed to their extensive use: 1) the dissatisfaction with large-scale MEMS and 2) major advances in solution techniques and development of software that facilitate quick and inexpensive applications. CGE models were applied to developing countries as early as the late 1970s and have now become a ubiquitous tool for applied economists.

In this section we review the basic structure of CGE models and look at the major areas of development. This is followed by a brief discussion on early CGE models in the Philippines. An inventory of CGE models in the period 1990-2002 is undertaken with emphasis on their applications. The list is not exhaustive and some of the models presented in the next section are not included. An evaluation of the state-of-the art in the Philippines and an assessment of CGE modeling in general form the core of the last part of the section.

Background[10]

The structure of a CGE model

The basic structure of a CGE model consists of the following components. First, one must specify the economic actors or agents whose behavior is to be analyzed. A simple Walrasian model would include only producers and households. Most CGE models add other actors such as government and rest of the world—additional institutions in the Social Accounting Matrix (SAM) framework. Second, behavioral rules must be specified for those actors that reflect their assumed motivation. For example, producers are typically assumed to maximize profits subject to technological constraints and households to maximize their utility subject to income constraints. Third,

[10]This section quotes heavily from Robinson (1989). Another useful overview of the basic structure of CGE models is provided by Bautista (1988), pp. 10-13. Chipman (1996) is also a useful reference.

agents base their decisions on signals they observe. For example, in a Walrasian model, prices are the only signals agents need to know. Fourth, one must specify the rules of the game according to which agents interact—the institutional structure of the economy. For example, assuming perfect competition implies that each agent is a price taker and that prices are flexible—markets exist and work perfectly.

With the specification of the agents, their motivation, and the institutional constraints under which they interact, a general equilibrium mode is still not completely determined. One must also define "equilibrium conditions," which are "system constraints" that must be satisfied but are not taken into account by any agent in making his decisions. Formally, an equilibrium can be defined as a set of signals such that the resulting decisions of all agents jointly the system constraints. The signals represent the equilibrating variables of the model. For example, a market equilibrium in a competitive model is defined as a set of prices and associated quantities such that all excess demands are zero. In a market economy, prices are the equilibrating variables that vary to achieve market clearing.

The SAM accounts provide the underlying data framework for CGE models, with an income-expenditure account for each actor in the model. The numerical SAM integrates national income, input-output, flow-of-funds, and foreign accounts into a comprehensive data set. The model is then calibrated by assigning values to the parameters based on econometric estimates, recognized standards, or results from other studies. The ultimate objective is to replicate the base period data set, which represents the equilibrium solution of the model.

Extensions of the basic CGE model

The neoclassical assumption of market clearing and full employment that is characteristic of the basic CGE model did not sit well with many modelers working on developing countries. They sought to extend the models in a variety of directions in order to capture "structuralist" features of developing countries. Unfortunately, this sparked a heated debate—which remains unresolved—between the purists and the structuralists. The latter contend that using a model with clean theoretical roots in a situation where its assumptions are not satisfied will not yield valid empirical results or aid in policy analysis. On the other hand, constraints imposed on the model by structuralists are essentially ad hoc in that they are not related to any endogenous rational behavior of agents.

This survey does not intend to resolve the debate but the major modifications to the basic CGE model are discussed. First, one can stay within the theoretical structure of the neoclassical model but specify limited substitution elasticities in a variety of important relationships. This type of model might be termed "elasticity structuralist" and has become the most commonly used by practitioners. One example of deviation from the standard model is the assumption that domestic goods sold in the domestic market are imperfect substitutes for imports. What demanders want is a composite commodity, which is a constant elasticity of substitution (CES) aggregation of imported and domestic goods—the Armington function. Nevertheless, the elasticity structuralist model is still within the purview of the standard neoclassical CGE model.

A second type, which can be called "micro structuralist," assumes that various markets do not work properly or are not present at all. Instead, there are assumed to be restrictions on factor mobility, rigid prices, rationing, and neoclassical disequilibrium in one or more important markets. "Macro structuralist" models represent a third type and focus on questions of achieving equilibrium among various macro aggregates; in particular, savings and investment, exports and imports, and government expenditure and revenue. Among the prominent exponents of the macro structuralist school is Lance Taylor. Their approach seeks to integrate macro models with multisector models, and so blend Keynes and Walras. The complications arising from the macro structuralist model are discussed in more detail by Robinson (1989).

Within the standard neoclassical model, there have been attempts to extend the structure without sacrificing theoretical soundness. These developments have been dealt with extensively (Gunning and Keyzer 1995) and a summary of the issues is presented in Table 1.

The introduction of dynamics as discussed in the Gunning-Keyzer survey article closely follows the DSGE approach (II-C), which is based on intertemporal optimization. In the early stages of CGE modeling, only recursive dynamics was applied. Periods were related through updating of some exogenous variables like the capital stock or demography. Standard practices for modeling imperfect competition were also discussed, but this was excluded from the list in Table 1 because there was no clear alternative to mark up pricing at that time.

Recent developments are less focused on theoretical issues. Traditional CGE models can only evaluate the evolution of inequalities between groups. Subsequent models have included information on intra-group income distribution. Using income and expenditure surveys, it is possible to generate

Table 1. Developments in CGE modeling

Standard Practice	Alternative
Fixed regime	Regime switches
Tax functions	External effects
Government as a consumer	Nonrivalness, empathy
Labor endowments given	Efficiency wage relation
Convex production set	Nonconvexity
Closure rules	Dynamics
Saving/investment function	Intertemporal decision
Transaction demand for money	Cash-in-advance
Money and financial asset demand	Incomplete asset market

Source: Table 35.2 of Gunning and Keyzer (1995), p 2101.

the within-income distributions prevailing in the year on which the SAM is based. However, in this type of model, it is still impossible to analyze intra-group inequalities even if it is well known that they contribute much more to the total inequalities than inter group income disparities (Decaluwé et al. 1999).

Hence, a third type of modeling approach was developed which relies directly on statistical information at the household level—the *microsimulation model*. The principle is to construct a CGE model with as many agents as there are in the survey in order to keep all the information about the heterogeneity with regard to endowment and consumption. However, the large amount of work and statistical information this approach requires casts doubt on the practical aspect of such modeling. A specific income distribution is usually identified and estimated to facilitate analysis.

Another recent development is *double calibration*.[11] With the help of a CGE model, data from two different years are used to isolate and evaluate the respective roles of all policy measures and other changes that occurred in an economy between those two years. This procedure may also help avoid the problem of having a base year that is clearly out of equilibrium.

The construction of regional CGE models would be possible in the near future with the completion of regional input-output tables by the National Statistical Coordination Board (NSCB). This would help address the concern regarding balance regional economic growth. However, the same problems that surfaced with the regional econometric model (Section I-E, *Other Models*) would likely constrain the regional CGE model.

Comparing CGE models and MEMs

The development of CGE models is considered part of the response to the critique of large-scale MEMs. Not only does CGE modeling use a different approach, it also addresses some of the major shortcomings of macroeconometric models. One, the paradigm proposes a well-specified theoretical model built on optimizing behavior of economic agents. Two, since the model is parameterized by calibration, the result is that the theory reigns supreme over the data. This is in sharp contrast to the MEM approach—particularly the LSE methodology—of having the empirical results determine the appropriate underlying theory.

CGE models also allow a systematic specification of the interdependence among sectoral prices, outputs and factor use, as well as a disaggregation of economic groups in terms of income generation and consumption patterns. This facilitates the analysis of policy changes on resource allocation and income distribution—an application to which macroeconometric models are inherently not well suited (Bautista 1988).

[11]Many of the recent developments in CGE models are discussed in an annual modeling course sponsored by the Modeling and Policy Impact Analysis research network. For access to some papers on recent developments refer to http://www.crefa.ecn.ulaval.ca/develop/mpia-training.htm.

Early CGE models of the Philippines

Path breaking work in CGE modeling of the Philippine economy can be attributed to Ramon Clarete, Cielito Habito, and Romeo Bautista. Later, a model was developed at the Kyoto Center for Southeast Asian Studies as part of the research on "policy evaluation models" for the ASEAN countries. These models and related work are reviewed by Bautista (1988).

The models of Clarete and Habito conform to the neoclassical tradition while Bautista's 1987 model contains structuralist features. Clarete's model even assumed domestic products and imports to be perfect substitutes. Their applications centered on the determination of economy-wide welfare or efficiency impacts and of the income distribution effects of alternative policy scenarios.

Clarete's studies dealt with the assessment of the deadweight loss, measured by the equivalent variation of income, associated with various domestic market distortions. By comparing the model's counterfactual equilibrium solutions and the base period equilibrium data set, Clarete estimated that tariffs and export taxes in the Philippines led to a deadweight loss amounting to 3.4 percent of national income. Meanwhile, simulations with Bautista's 1987 model showed a rise in national income of 1.6 percent associated with a uniform reduction in sectoral tariff and export tax rates by 30 percent, and an increase of 2.8 percent associated with the complete removal of export taxes and changes in sectoral tariffs to a uniform rate of 10 percent.

CGE models of the Philippine economy: 1990-2002

CGE models differ in terms of underlying theory (neoclassical vs. structuralist), size (or level of disaggregation), delineation of households (size distribution or special classification), solution procedure (fixed point, numerical method, or matrix inversion), model closure, and whether the model is static or dynamic. Three CGE models are presented in this section. The first represents the neoclassical tradition while the second is an example of a macro structuralist model. The last model, which is one of the more recent models, would be indicative of the current state of CGE modeling in the Philippines.

The APEX model[12]

The APEX CGE model, which is an acronym for Agriculture Policy Experiments, was developed by Ramon Clarete, Peter Warr and their associates. The standard citation is Clarete and Warr (1992), whose initial version used a 1989 data base. Up till the middle of 2001, it was the most disaggregated CGE model with 50 production sectors. The agricultural sector is represented by 16 subsectors starting from rice (disaggregated further into irrigated and nonirrigated or rain-fed rice), up to forestry. The industrial

[12]This description of the APEX model draws heavily from the appendix of Cororaton (1997).

sector has 28 subsectors, 24 of which are under manufacturing. The service sector is represented by six subsectors.

The APEX model is a neoclassical, Walrasian CGE model with a well-defined production (or supply) sector, as well as a consumption (or demand) sector. The two sectors are cleared via price adjustments. The APEX model belongs to the Johansen class of CGE models wherein the system of equations are linearized in percentage changes of the variables. To illustrate, consider a two-sector model whose production function can be written as:

$$Y = f(X_1, X_2) \qquad (13)$$

where Y is output and X_1 and X_2 are inputs. In a Johansen-type model Equation 13 is rewritten in linear percentage change form as

$$y - e_1 x_1 - e_2 x_2 = 0 \qquad (14)$$

where e_i is the elasticity of output with respect to inputs of factor i and the lower case variables y, x_1, and x_2 are percentage changes of Y, X_1 and X_2, respectively.

In matrix notation, this type of a model can be written as:

$$\mathbf{Az} = \mathbf{0} \qquad (15)$$

where **A** is an $m \times n$ matrix of coefficients and **z** is an $n \times 1$ vector of variables expressed as percentage changes. Since **A** is assumed fixed, (15) provides only a local representation of the equations suggested by economic theory, i.e., the equation is valid only for "small" changes in X_1 and X_2. However, linearization errors can be reduced or even eliminated by using an iterative procedure developed by the authors of the Australian ORANI model on which APEX is patterned. The Johansen procedure allows the model to be solved by simple matrix inversion.

Through an appropriate closure, **z** may be partitioned into a vector of endogenous variables **y** and a vector of exogenous variables **x**. This allows Equation 15 to be rewritten as:

$$\mathbf{A_1 y} + \mathbf{A_2 x} = \mathbf{0} \qquad (16)$$

Provided $\mathbf{A_1}$ is invertible, a solution can be found for **y**. Much of the flexibility in CGE models lies in the ability to swap exogenous and endogenous variables.

The 50 sectors of the APEX model are classified as agriculture and nonagriculture. Three primary factors are mobile among the various nonagricultural industries, namely, variable capital, skilled labor, and unskilled labor. Variable capital includes nonagricultural land and structures which are not necessarily devoted to any particular line of production activity such as buildings and related fixed structures. Thus, when relative prices change, owners of such land and capital assets can rent these assets out to producers who face more favorable terms of trade. Unskilled labor is also freely mobile between the nonagricultural and agricultural sectors in the model. However, skilled labor (defined to as having a high school education or better) and variable capital are not used in agriculture, and are mobile only among the nonagricultural industries of the model.

There are five household groups in the model based on income quintiles, with the first quintile being the lowest-income bracket. Households are assumed to have their own endowment of primary factors, i.e., they derive their income from the sale of factor services and nonfactor income. The sources of household income include labor income, returns to variable and fixed capital, and rental income derived from renting out their farm lands for primary agricultural production. The households' nonfactor income consists of lump sum net income transfers from the government.

There are seven consumer goods and services which are directly consumed by the various households in the model. The consumed amount of each of these consumer commodities and services is used as an argument in the underlying utility functions of the various households. Unlike producer goods, consumer goods production requires only intermediate goods as inputs, and not primary factors.

Household savings determine the total savings available for investment. The model assumes that only physical capital assets are obtainable using such savings. Financial assets such as bonds, equity and bank deposits are not incorporated into the model. With this level of savings, additional units of physical capital are produced during the current period. This capital is then allocated to each sector-specific capital goods and variable capital, using the relative user cost of such capital inputs.

An implicit financial assets market is assumed to exist whereby every household buys claims to each type of the fixed and variable capital stock. Such claims entitle the household to a portion of the newly produced capital during the current period. On the other side of this implicit market are the supplies of fixed capital for each of the 50 sectors and the variable capital. Their respective entitlements are then used by households to update their endowment in capital inputs, both fixed and variable.

Various industries of the model are classified as either export-oriented or import-competing. The criterion used to classify these industries is the proportion of an industry's imports to its exports. If the ratio exceeds 1.5, then the industry is regarded as producing importables. The observed exports of this industry are regarded as exogenous in the model. However, if the ratio is less than 0.5, then the industry is considered export-oriented. For ratios between 0.5 and 1.5, other relevant information were utilized to classify the corresponding sectors.

The APEX model assumes the country to be a price taker for its imports. As in most other CGE models, it assumes imperfect substitutability between imports and locally produced products through the use of the Armington trade elasticities. Meanwhile, export demand equations in the model have relatively large but finite elasticities. As such, the country can be regarded as a price taker in a particular commodity in the world market.

The model is closed using fixed foreign capital inflows. This implies that equilibrium in the external sector is reached through adjustments in the foreign exchange rate. On the domestic sector, equilibrium is reached through adjustments in domestic absorption. Adjustments are done until savings and government balances equate to zero. The model does this by introducing a lump sum tax which assumes a positive (negative) value whenever the government incurs a deficit (surplus). This tax is captured in the model by introducing a personal income tax rate shifter. The shifter scales this rate up or down depending upon whether the government is in deficit or surplus.

One important feature of the APEX model is that it uses empirically estimated behavioral parameters in its structure. Thus, almost all of the elasticities in the production, consumption, and trade sector were estimated econometrically using Philippine data.

Diagnostic tests done on the model yielded some puzzling results (Cororaton 1994). For example, an increase in the tariff levels by 10 percent resulted in a marginal increase in GDP. However, 44 out of the 50 sectors experienced an output decline. The quirks in the model were remedied in subsequent work. Using the APEX model but with exchange rate fixed, Cororaton (1997) assessed the impact of the Philippine's accession to the WTO. The overall results indicate a positive impact, but this accrues from the growth in global trade and output. There is minimal change in the tariff structure as many of the tariffs are below the stipulated bound rates under GATT/WTO.

The APEX model was subsequently updated using 1994 data (Cororaton and Cuenca 2000). This was used to examine the trade reforms between 1995 and 2000. Tariff changes were simulated based on three measures: nominal tariffs, implicit tariffs, and the ratio of export value—the value of the Philippine's imports from country of origin—and invoice value or the value of imports based on invoices. The study also analyzed the possible effects of the shift in the method of valuation of imports from the home consumption value method to the transactions value method. The results showed that lower tariffs—using either three measures—would yield higher output and a better structure of income distribution. The lowest quintile generally obtained the highest increase in income.

A macro structuralist model

A dynamic financial CGE model was developed for the Philippines to analyze the impact of structural adjustment and stabilization policies brought about by the external debt problem (Vos and Jemio 1993). This model was considered for the MIMAP project (Cororaton 1996) from which the description in this paper was obtained.

The Vos-Jemio model contains six production sectors and specifies the behavior of seven agents or institutions: households, private corporations, public corporations, government, central bank, private financial institutions, and public financial institutions. It specifies the asset accumulation behavior of the different agents that determines investment activity. The types of assets incorporated in the model are: physical capital—both unincorporated capital and corporate capital—and financial assets—money, government securities, bank deposits, and foreign exchange. Dynamics are introduced primarily in the recursive manner.

The structuralist nature of the model is apparent in the explicit constraints that bind investment demand. The investment pattern of each institution is affected by various constraints: domestic finance and foreign exchange availability. This can be explained by the following equations:

$$IR = \min(IRF, IRE, IRB)$$

IR is realized investment, *IRF* is the accelerator determined investment demand, *IRE* is the foreign exchange constrained maximum possible level of investment, and *IRB* is the finance constrained maximum possible level of investment. *IR* is the minimum of these three values.

The accelerator determined investment is obtained from the following function:

$$IRF_t = \beta_0 + \beta_1 IR_{t-1} + \beta_2 (GDP_t - GDP_{t-1})$$

This is another channel by which dynamics are introduced into the model. The foreign exchange constrained maximum possible level of investment is a function of import capacity:

$$IRE_t = IR_0 \cdot (CM_t / CM_0)$$

The capacity to import CM is determined through the availability of foreign exchange. The "0" indicates the base year.

The level of finance constrained investment *IRB* is determined via the balance sheets of the different institutions, which were obtained from flow-of-funds data. Elements of the balance sheets vary as a result of portfolio choice behavior. Demand for various assets depends on their relative profitability, which is determined by the interest rates on the different financial assets and the exchange rate. The asset demand functions are specified as CES-type.

The official exchange rate is exogenous in the model and affects imports and exports. However, the model also specifies a parallel exchange rate, which clears excess demand in the parallel market. This consists of transactions involving factor payments and current transfers received by households from abroad and household demand for foreign assets.

Since the official exchange rate is exogenous, the model is closed through changes in the central bank's foreign exchange reserves. However, when the reserves of the central bank are exhausted—or fall below a minimum threshold—import capacity becomes the closure mechanism of the model. When this occurs, the central bank adjusts its credit to the private sector, the credit of development banks to households is also affected, government institutions curtail investment spending, and private firms respond in a similar manner.

This model was applied to analyze the performance of the Philippine economy in the period 1987-1992 and determine the importance of various macroeconomic constraints (Vos and Yap 1996). The issues that were addressed included: 1) whether higher capital inflows or greater debt reduction would bring about substantial increases in economic growth; 2) the response of domestic resource mobilization to higher capital inflows; 3) the possible trade-off between trade and fiscal objectives when pursuing a more realistic exchange rate policy; and 4) the possibility of overly tight fiscal and monetary policies. The interested reader could refer to the aforementioned reference for a discussion of the results.

The Tariff Commission model

The TARFCOM model has replaced the APEX model as the most disaggregated CGE model of the Philippines (Horridge et al. 2001). It is largely based on the ORANI-G model of Australia and thus shares many features of the APEX model. The large version is composed of 229 sectors but this can be aggregated to the "small version" consisting of 43 industries. Data for the model are based primarily on the 1994 input-output table.

To simulate the steady-state effects of policy reforms, the authors adopted long-run closures. In particular, the ratio of the balance of trade deficit to GDP is made exogenous, with real aggregate consumption expenditure determined endogenously. The model was constructed to analyze the impact of competition policy but other simulation exercises were also undertaken.

The model consists of only of one representative household. Hence it cannot be used to assess the income distribution effects of policy changes. However, the authors disaggregate the output impact across the different regions in the Philippines. This is done by distributing output changes according to the share of each region—which is apparently fixed—in the output of a particular industry.

Efficiency gains from competition policy can be modeled more convincingly similar to the method applied by Coxhead and Warr (1991). Using the following AMFM equation for illustrative purposes, $f(lt, \bar{k}_{-1}, m) = A_{CD} lt^{\beta_1} \cdot m^{\beta_2} \cdot k_{-1}^{1-\beta_1-\beta_2}$, the TARFCOM model simulates efficiency gains by simply adjusting the constant A_{CD}. A more elaborate procedure can be used that would identify the factor bias of the efficiency gain.

A brief perspective on CGE modeling

CGE modeling has received its fair share of criticism.[13] As mentioned earlier, the standard model adheres very closely to the full-employment, market-clearing paradigm, which limits its applicability to developing countries. The macro structuralist models are not problem-free either. However, a more important consideration is that the policy implications flowing from these models are often built into them by construction (Hall, 1995).[14]

Validating a CGE model empirically is also difficult. The only criteria available are its replication of the base year data and reasonable simulation results when applied to policy evaluation. Comparing historical data and predicted results is not feasible extended time series for many of the variables of the CGE model are not available.

Replicating the database is virtually assured, since at the very least, the model builder has at his disposal the adjustment of constants in the equations. Theoretical intuition, rather than historical verification, then becomes the basis for model validation (Bautista 1988).

The developments in CGE modeling cited earlier seek to overcome some of the shortcomings of the early models. However, judging from the models that were reviewed (and others cited in the next section), progress in Philippine CGE models seems to have reached a plateau. Practically none of the identified advances have been incorporated. In fairness to the modelers, their attention has been directed toward policy issues, which demands a great deal of time. Because of this constraint, the outcome is often simple extensions of existing models. Hopefully, many of these issues would have been resolved by now, enabling practitioners to focus their efforts on improving the structure of CGE models.

Early CGE models for developing countries focused on income distribution. This arose from the growing concern that rapid growth and structural change did not suffice to reduce poverty and that large groups of poor people where not benefiting from growth (Robinson, 1989). In sharp contrast, MEMs largely ignored this issue, which was more of a problem of neglect rather than modeling constraints, although as noted earlier CGE models are more suited to this type of analysis. The focus in this section will be on applying MEMs and CGE models to analyze social issues to wit, income distribution, population, education, health, nutrition, poverty and the environment.

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[13] It has been told that when the CGE methodology was described to him, the late Dean José Encarnación exclaimed: "Witchcraft!" See introduction of de Dios and Fabella (1996).

[14] A clear example is a comparison of two working models for South Africa, one neoclassical and the other structuralist (Gibson and van Seventer, 1999). Simulation results show that the former fully supports the principles of the "Washington Consensus" while the structuralist model requires a far more heterodox set of policies to avoid slow growth or high inflation.

Income distribution

Analysis of the impact of macroeconomic developments on income distribution is not new. An exhaustive review of global efforts in this area up till 1991 is provided in Yap et al. (1994). However, income distribution was hardly ever analyzed in the context of a MEM. The different methodologies fall under either the time-series approach, the simulation approach, or the use of CGE models. This classification can be extended to modeling other social outcomes like health and nutrition. Table 2 shows the impact of a reduction in the tariff level on income distribution using various models. This table serves as a useful summary and guide to subsequent discussions.

The time series approach examines actual historical changes in size distribution of income and attempts to relate these changes to those in macroeconomic conditions. One example was a study that estimated an equation relating the Gini coefficient to variables such as inflation, unemployment, the growth rate, and time trend. The main drawback of this approach, particularly in developing countries, is the unavailability of a consistent set of time series data on size distribution of income. And even if these were available the coverage may not be long enough.

Table 2. Impact of tariff reduction on output, welfare and income distribution

Model	Reference	Impact on Output Welfare	Impact on Income Distribution
APEX, 1989 data	Cororaton (1996)	positive	positive
APEX, 1994 data	Cororaton and Cuenca (2001)	positive	positive
Macro structuralist	Cororaton (1997b)	positive	negative
Macro structuralist, 10 year simulation period	Cororaton (1998)	overall positive	overall positive except for lowest income decile
Neoclassical CGE	Aldaba and Cororaton (2001)	positive	positive
Neoclassical CGE	Inocencio, et al. (2001)	positive	negative
Macro composite model	Yap (1997b)	positive	negative
NEDA AMSM, 5 year simulation period	Reyes and Constantino (2000)	negative	N.A.

The simulation approach involves taking cross-section data on incomes of individuals/families for a particular year, usually from sample surveys, and examining the impact on the size distribution of certain specified changes, while holding all else constant. Changes in key variables are usually generated using a macroeconomic model.

Linking the PIDS-NEDA annual model and the Dagum model of income distribution

A study on income distribution in the Philippines determined that the density function developed by Camilo Dagum appropriately represented Philippine data (Bantilan et al. 1994). The cumulative density function of the Dagum model is given by:

$$F(x) = \alpha + \frac{1-\alpha}{(1+\lambda x^{-\delta})^{\beta}}$$

The parameters α, β, λ, δ can be given economic interpretations.[15] A positive value of α implies that the distribution starts at the left of the origin and allows for the case where a certain proportion of the population may have nil or negative incomes. For sample surveys dealing with members of the labor force and considering the earned income, α may be considered as a pure rate of unemployment. Meanwhile, an analytical expression for the Gini coefficient G can be derived from the density function and it can be shown that:

$$\frac{\partial G}{\partial \beta} < 0 \text{ and } \frac{\partial G}{\partial \delta} < 0 \text{ for b} > 0 \text{ and d} > 0$$

This indicates that β and δ can be interpreted as equality parameters as the Gini is a decreasing function of both. This result can be useful when linking these parameters to macroeconomic variables.

The latter approach was attempted by Yap et al. (1994) but did not yield useful results because of the large volatility of macroeconomic variables compared to the estimates of the parameters of the Dagum distribution. Instead, percentile ratios were calculated and estimated as a function of selected maroeconomic variables. This approach was facilitated by the some analytical results. If $R_i = \frac{P_i}{P_{50}}$ is the ratio of the i^{th} percentile to the median, the following conditions were shown to hold:

[15]The discussion on the interpretation of the parameters is lifted from Bantilan et al. (1994).

Case 1: If $i < 50$, then $\frac{\partial R_i}{\partial \beta} > 0$ and $\frac{\partial R_i}{\partial \delta} > 0$

Case 2: If $i > 50$, then $\frac{\partial R_i}{\partial \beta} < 0$ and $\frac{\partial R_i}{\partial \delta} < 0$

Combining these conditions with those relevant for G led to the following:

$$\frac{\partial G}{\partial R_i} < 0 \qquad \text{if } i < 50 \text{ and } \frac{\partial G}{\partial R_i} > 0 \qquad \text{if } i > 50$$

An increase in R_i will lead to an improvement in income distribution (fall in G) if $i < 50$ and would cause income distribution to deteriorate (increase in G) if $i > 50$. The idea was to find macroeconomic variables that will move R_i in opposite directions depending on whether the i^{th} percentile is less than or greater than 50. One such variable was the ratio of compensation of employees to GDP (COMP/GDP). Regressing R_i to macroeconomic variables rendered the methodology to be classified as a time-series approach.

Policy analysis was then applied by using the PIDS-NEDA annual macroeconometric model to generate values of COMP/GDP. The simulated percentile ratios were then used to generate an income distribution that followed the Dagum density function. This allowed the generation of both a baseline income distribution and one derived from the "shock" run. For example, a currency depreciation led to an improvement in the income distribution but a lower level of output. On the other hand, an increase in capital outlays caused the economy to expand but at the expense of a higher Gini coefficient.

Work on applying the Dagum model to Philippine data has ceased. If in the future, microsimulation analysis of poverty and income distribution is deemed feasible, then the use of the Dagum model can be revived.

CGE analysis with emphasis on income distribution

Analyzing income distribution using CGE models is an extension of the simulation approach, whereby parameters of the model are derived from a baseline period. A useful example is the model in Coxhead and Warr (1991). They constructed a stylized model that describes a small open economy in which three commodities are produced in four sectors. Two sectors produce a single agricultural good, the third sector produces services, and the fourth manufactures. The equations in the model fall into four groups. The first two describe, in turn, factor demand and product supply, and the supply of mobile factors. The third set of equations describes the activities of households as earners and consumers. The fourth group determines prices of factors and of the nontradable commodity (services).

The household income equation in their model is specified as:

$$M_h = \delta_{hl}(1+\varepsilon_{hl})\cdot w + \delta_{hk}(1+\varepsilon_{hk})\cdot r + \sum_{s=1}^{4}\gamma_{hs}(z_s + Z_s) + \delta_{hl}\cdot L + \delta_{hk}\cdot K$$

Sectors are indexed by *s*, households by *h*, and the subscripts *l* and *k* denote labor and capital, respectively. The model belongs to the Johansen class of general equilibrium models, meaning that the variables are expressed in proportional changes. The definitions of variables and parameters are as follows:

M_h	- income of household group *h*
δ_{hi}	- share of income of household group *h* derived from earnings of factor *i*
ε_{hi}	- own-price elasticity of supply of factor *i* from household group *h*
w	- price of labor
r	- price of capital
z	- return to specific factor in sector *s*
Z	- endowment of fixed factor specific to factor *s*
γ_{hs}	- share of income of household group h derived from earnings of specific factor Z_s
L	- aggregate labor endowment
K	- aggregate capital endowment

Variations in income distribution are brought about by movements in factor incomes *w* and *r*, both of which respond to policy changes. On the other hand, the parameters δ_{hi} and ε_{hi} are invariant to policy changes. Seven categories of households are identified based on certain characteristics—landless laborers, small farmers in irrigated area, etc. A classification based on size distribution can also be used.

The model was calibrated using Philippine data and was used to simulate the effects of technical change. Their results draw attention to the fact that interests of owners of fixed factors do not necessarily coincide; returns to different fixed factors, or to the same fixed factor used in different sectors, may, and frequently do, move in different directions. Related studies can be found in Coxhead and Warr (1995) and Warr and Coxhead (1993).

A similar approach was applied by Balisacan (1995) in dealing with the issue of poverty. He developed a poverty measure based on the gap between actual consumption and a threshold poverty consumption level, and the concept of "equivalent income." The poverty measure is a function of the prices of basic commodities, movements of which were derived from a CGE model. Using data from the 1988 and 1992 FIES, Balisacan showed that the short-run effect of a rise in commodity prices that results from a currency devaluation is an increase in aggregate poverty, even within the agricultural sector. Particularly vulnerable are the numerically large small agricultural producers and landless workers who are net buyers of food.

4
Quantitative Models with a Human Face

MIMAP models

After the second oil crisis in 1977-78 and international debt crisis in 1982, policymakers in developing countries turned their attention away from income distribution issues and focused on questions of stabilization and structural adjustment. The central theme was to analyze the impact of the lower level of foreign resources on the structure of production and trade. It was only after several countries suffered drastic cuts in output that economists realized the repercussions of these policies at the household level. The International Development Resource Centre (IDRC) of Canada made this its primary concern when it launched the project on MIMAP. Research efforts included the development of quantitative models to study social outcomes in empirical terms.

The basic framework showing the transmission process from macro to micro is depicted in Figure 1. While the diagram is focused on health, nutrition, and education, income distribution and environment can readily be incorporated.

Income distribution

In the Philippines, one study estimated the impact on income distribution using a macroeconometric model. This was attempted with the PIDS-NEDA Annual Macroeconomic Model (Yap 1997b) in what can be described as a simulation approach. The macroeconomic model was used to generate value added in 11 major sectors of the economy: Agriculture, manufacturing, mining and quarrying, construction, electricity gas and water, transportation, communications and storage, trade, finance, private services, government services, and ownership of dwellings and real estate. Data from the National Income Accounts show how value-added per sector is distributed among three categories of factor income: Compensation of Employees (COMP), Mixed Income (MIX) and Operating Surplus (OS). The first category is roughly equivalent to wages, with OS taken to be equivalent to profits while MIX is taken to be income from self-employment.

The SAM accounts provided the mechanism by which factor income was translated into household income. Households were classified according

Figure 1. Analytical framework for assessing the Micro Impact of Macroeconomic Adjustment Policies on health, nutrition and education

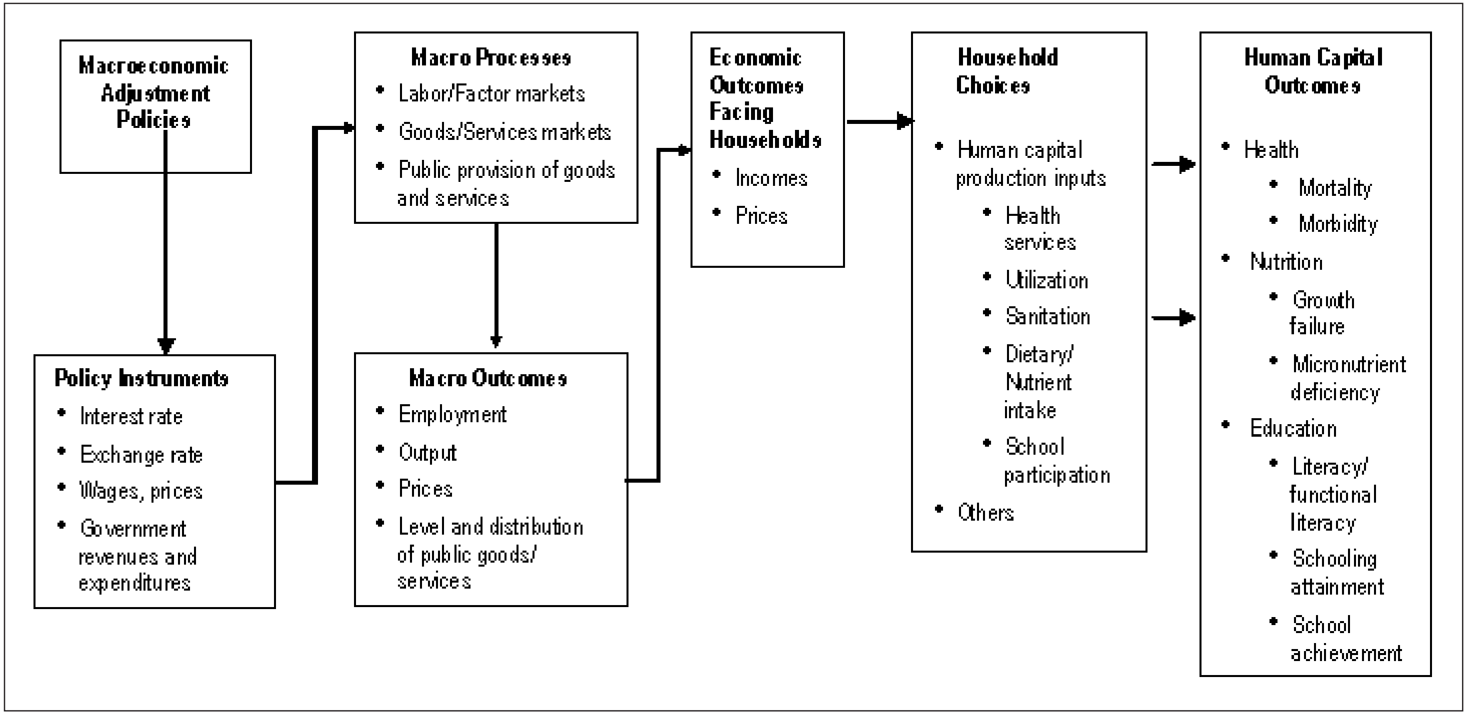

Diagram version of Table 1 of the same title in Herrin (1992).

to size distribution based on deciles. When doing simulation exercises, a fundamental assumption was that the change in the total amount of household income from each source affected each recipient of income from that source proportionately to the amount received from that source. These proportions were assumed to be fixed, not unlike the case of CGE models where the parameters in the household income equations are constant. In other words, any changes in the factor incomes COMP, MIX, and OS are distributed across households in fixed proportions. While this may have been true in the short-run, structural reforms likely altered the composition of income sources of the different households in the medium term. Given historical trends, however, the extent of such a change was expected to be small.

The simulation results indicated that structural reforms that favored economic growth also tended to favor higher income groups and thus exacerbated income inequality. This result was reflected in the 1997 FIES, which showed a sharp deterioration in income distribution with the Gini ratio rising to 0.49 from 0.45 in 1994. These results—which are consistent with the composite model involving the Dagum income distribution function—stemmed mainly from the sectoral impact of structural reforms. The value-added of the production sectors which benefited the most from the deregulation and liberalization measures accrued primarily to the upper income groups, i.e., the ninth and tenth deciles.

Household models: food and nutrition

Both the macroeconometric model and CGE model could be used to generate results that would feed into the MIMAP household models. The objective of the latter is to determine how households incorporate changes in incomes and prices in their decisions. The general methodology can be described as a simulation-type approach. The major disadvantage of the household models is the absence of a feedback mechanism from the social outcomes to the macroeconomy.

The first is a model of nutrition status of households (Orbeta and Alba 1998). Applying the Almost Ideal Demand System—with some modifications—price and demand elasticities of food are estimated using nationally representative sample survey data. The change in the AIDS framework consisted of adding household characteristics, namely, traits of the household head such as age and education, age composition of household members, and regional dummy variables.

The percentage change in the demand for a food item, $\hat{q}_i$, can be expressed in percentage terms as follows:

$$\hat{q}_i = \sum_j \epsilon_{ij}\hat{p}_j + \eta_i\hat{x}$$

where ϵ_{ij} is the uncompensated price elasticity, $\hat{p}_j$ is the percentage change in the price of commodity item j, η_i is the expenditure elasticity and $\hat{x}$ is the percentage change in expenditure. Separate sets of equations were estimated for five income quantiles. One can then use the average contribution of each food item to specific nutrients of interest to derive the implications of macroeconomic policy changes on nutrient consumption of households using the relation:

$$\hat{N} = \sum_i K_i \hat{q}_i$$

where K_i is the initial nutrient contribution of commodity i.

The impact of tariff reform program on the prices of the different food items were obtained from the APEX model (Cororaton 1996b). The results indicated that, except for beverages, price of food items declined following the reduction in tariffs. As a result of this decline in prices, households increased their demand for most of the food items except for the highest income quintile, where only the demand for cereal, fish, and other food increased. The tariff reform program also yielded a progressive increase in income.

After translating the changes in food demand into calorie and protein availability in households, the findings showed that the tariff reform program was even more progressive in terms of macronutrient availability in households. The authors concluded that the traditional results of simulating general equilibrium models, which stop at the impact on income distribution, can be enriched by explicitly dealing with the impact of price and income changes on household decisions.

Household models: demand for health care

Another study dealt with household choice of health care facility via estimated price and income elasticities (Orbeta and Alba 1999). A discrete choice model of outpatient care was estimated using data drawn from a household survey covering four regions and seven provinces involving 2,798 households and some 14,200 individuals. The choice alternatives included home care and formal care, which consists of hospital outpatient clinics, independent private clinics, and public or charity clinics. Both simple and nested logit model specifications were estimated.

The empirical results showed that prices or user fees and income are important determinants of health care choice. Moreover, there is a clear tendency for bigger price elasticities among lower income households. This implies that uniform price increases will hurt the poor more than the rich. Another key feature of the model is that home care and public/charity clinics have negative income elasticities. On the other hand, hospital outpatient care and independent private clinics have positive income effects. In addition, the income elasticities are lower for low-income households. In other words, everything else equal, an income change will produce larger responses from the higher income groups.

Applying the same inputs from the CGE model as the nutrition model, the impact of the tariff reform program was simulated. Apart from food prices and income distribution effects, the CGE simulations generated prices of public and private health care services. The assumption was that changes in prices of private health care services applied to hospital outpatient and independent private clinics while the changes in public health care prices applied to home care and charity clinics. The actual results showed that the tariff reform program led to an increase in the cost of private health care and a decline in the cost of public health care. As mentioned earlier, the positive impact on income was generally progressive.

In terms of choice of health care facility, the results showed that households in lower income groups used less hospital outpatient and independent private clinics and depended more on home care and public or charity clinics. The progressive income effect of the tariff reform program was insufficient to offset the increase in prices. Only the households in the highest income quintile were expected to increase their use of private services despite the increase in the price of the latter.

Household models: school attendance

Two models were developed to estimate the impact of changes in income and prices on: 1) parental decision to send a school-aged child to school; and 2) the decision between schooling and labor force participation (Orbeta and Alba 1999b; Orbeta 2000). The first is a discrete choice model of school attendance for children from 7-14 years of age. The child-specific characteristics that were found to be statistically significant are age, sex, and educational attainment. The important household characteristics are age and educational attainment of the household head, and consumption expenditures net of educational costs. Meanwhile, the community characteristics that were found to significant are the student-teacher ratio and residence dummies. Only households in the last three income deciles were included in the estimation.

Inputs from the CGE model that were based on the impact of the tariff reform program were different from the previous two household models. A 10-year simulation period was used in this case (Cororaton 1998). Income and price changes fed into net consumption expenditures. During the period 1990-95 when prices of education rose and incomes either declined or did not change, a fall in average school attendance was predicted. The period 1996-2000 showed the opposite results.

The second model is a bivariate probit of the joint schooling and labor force participation of the population in the 10-to-24-year-old bracket. For school attendance, the statistically significant person-specific determinants are sex, age, and educational attainment. The important household determinants are age, sex, educational attainment of the household head, and per capita expenditure. Meanwhile, the price of schooling, wage, and region of residence are the significant community variables.

For labor force participation, age, sex, educational attainment is the important individual-specific determinants. The significant household variables are the age and educational attainment of the household head, and the age composition of household members. The wage rate, unemployment rate, and public expenditure per school-age child are the important community variables.

The transmission variables between macroeconomic policy changes and the household decision between school attendance and labor force participation are income, price of education, wage, expenditure on education and the unemployment rate. Using the same inputs from the CGE model, Orbeta showed that the impact of the tariff reform program was a decline of the proportion of this age group that is attending school and an increase in the proportion that is in the labor force. Moreover, the proportion of working students increased and the proportion of idle children fell. Finally the program caused a decline in the proportion of pure students. The effects are all more pronounced in the period 1996-2000.

The NEDA Annual macrosocial model

An earlier study by Joseph Lim of the University of the Philippines was combined with the structure of the Reyes-Yap version of the PIDS-NEDA macroeconomic model to arrive at the AMSM (Reyes and Constantino 2000). This model is used by NEDA-NPPS in a similar way as the QMM. Like the quarterly model, but not the PIDS-NEDA model, the AMSM applied the Engle-Granger two-step procedure to the majority of behavioral equations.

The AMSM also has more detailed financial and fiscal sectors. A notable feature is a transmission mechanism linking foreign borrowing or monetary accommodation of the deficit, on the one hand, and monetary aggregates, on the other. Similar to the NEDA QMM, an equation for expected inflation was specified with structural factors as explanatory variables. However, capacity utilization does not appear in the equation for expected inflation although it is an explanatory variable in the equation for the general price level. Not unlike the NEDA QMM and AMFM, model-consistent expectations are not derived in simulation exercises. Expected inflation also determines real interest rates, which in turn feeds into the fixed investment equations.

The central feature of the AMSM is a feedback mechanism between social sector outcomes and the real sector, which is specified and estimated based on the time-series approach. The education outcome is represented by the combined elementary and secondary participation rate (PRTOT). This is determined by government expenditures in education, per capita consumption, and the real price of services, which serves as a proxy of the cost of education.

Meanwhile, the nutrition outcome is represented by the malnutrition rate (MALN). The nutritional outcome is determined by per capita consumption and the implicit price of agriculture relative to the general price level. An attempt was made to model health status as indicated by infant mortality rate and child mortality rates. However, no equation with a proper fit was obtained.

The education and nutrition outcomes affect the quality of the labor force. A novel way of linking quality of labor to the real sector was used via a measure of total factor productivity *TFP*. The latter was derived as follows. Value-added in the combined industry and services sector *VISR* was first estimated as:

$$\log \hat{VISR} = 2.85 + 0.375 \cdot \log(K46) + 0.51 \cdot \log(IEMP + SEMP) + 0.221 \cdot DUM6783$$

where K46 is an estimate of the capital stock while *IEMP* and SEMP are employment levels in the industry and services sectors, respectively. The "^" indicates that an estimated value is obtained from the equation. The potential value added in these two sectors *POTVISR* is obtained by substituting *LF-AGEMP* (labor force less employment in the agriculture sector), which is the maximum number of workers that can be employed in the two sectors.

$$\log POTVISR = 2.85 + 0.375 \cdot \log(K46) + 0.51 \cdot \log(LF - AGSEMP) + 0.221 \cdot DUM6783$$

TFP is estimated as:

$$TFP = \left(\frac{\hat{VISR}}{VISR} - 1 \right) \cdot POTVISR$$

This is intended to be a measure of the proportion of POTVISR attributable to the quality of labor inputs. VISR is actual valued-added in the two sectors.

The equation for TFP was estimated to be:

$$TFP = -0.395 - 0.0019 \cdot MALN + 0.0049 \cdot PRTOT$$

The latter then feeds into potential output, which determines the rate of capacity utilization, which is defined as:

$$CAPUT = \frac{\hat{VISR}}{POTVISRLF + TFP}$$

The model was used to simulate the impact of a currency depreciation, hike in oil prices, and restoration of tariffs to their level in 1995, which entails an increase in the average tariff. The higher price level and lower output brought about by the currency depreciation led to a slight increase in the malnutrition rate and a very slight decline in the enrollment rate. Meanwhile, the increase in oil prices generated counterintuitive results as the price level barely rose in the period when the shock was applied and even declined two periods later. GDP actually expanded in three of the four simulation periods. The social outcomes were not reported.

The tariff exercise also produced counterintuitive results as GDP increased after the level of tariffs was raised. The authors attribute this to a J-curve effect wherein the long-run gains of a counterfactual fall in tariffs are not captured in the simulation run because of its relatively short period. The social outcomes were also not reported in this exercise.

The structure of the social sector can be questioned on the basis of the timing of the impact. Changes in education and nutrition have relatively long gestation periods, and one should expect a lag in the impact of changes in these variables on the real sector, including productivity. The same is true for the feedback mechanism from the real sector to social outcomes. In particular, expenditure on education and health will have lingering effects. Unfortunately, the availability of data constrains the application of a reasonable lag structure.

Using a TFP measure also subjects the model to the criticism raised by the nihilist view. Analysts have shown that the TFP measure obtained from an aggregate production function is simply a weighted average of the growth rate of the return to capital and the return to labor. The whole process is nothing more than an exercise in validating accounting identities.

Population development models

Population development models, which capture feedback mechanisms from demographic factors to economic variables, have a long tradition in the Philippines. Pioneering work was done at the University of the Philippines School of Economics under the supervision of the late Dean José Encarnación. Subsequent efforts led to the development of the Population and Development Planning (PDP) model, which was first constructed by Vicente Paqueo and Alejandro Herrin of the UPSE and later modified by Aniceto Orbeta Jr. of PIDS. All these studies are carefully documented in a survey article by Orbeta (1996).[16] The latest version of the PDP model that is maintained at NEDA was updated in 1999 to reflect the 1995 census data.

In the PDP model, demographic factors affect the labor market, where labor supply is computed as the product of the labor participation rate and population 15 years and over. The labor participation rate was initially exogenous but later endogenized on an age-specific basis. Private consumption is partly determined by the population structure via the youth-dependency ratio while government consumption expenditures is affected by population size.

Meanwhile, population size also affects output for agriculture through a land scarcity indicator. The latter responds to demand for land, which is the variable directly affected by population size.

The demographic model consists of an abridged life-table driven by infant mortality rate; equations estimating age-specific female population, which were primed up by the number of births; and the survivorship functions implied by the life-table. The marital general fertility determines the number of births in each period. Subsequent versions of the model developed age-specific fertility equations allowing the computation of total fertility rate.

The infant mortality rate, the marital general fertility rate, and the proportions of households living in rural areas are functions of socioeconomic variables. It is through these variables that economic development affects demographic outcomes. Later versions of the model added equations to study

[16]The rest of the discussion in this section quotes heavily from Orbeta's survey article.

the implications of human capital expenditures and women status in the course of economic and demographic development.

Simulation results were conducted to study the importance of alternative demographic scenarios. It was shown that population growth hampered development efforts, which was reflected in lower GNP growth rate, lower per capita income, higher unemployment rate, declining real wages, and slower rate of structural transformation. Some results complemented the objective of MIMAP, which showed that policies that caused an economic contraction resulted in a higher infant mortality rate.

Subsequent simulations that were conducted to determine the importance of human capital expenditures on socioeconomic development yielded these results: 1) human capital expenditures generally rise with rapid population growth, but the increase is insufficient to maintain per capital levels, implying that the quality of human capital will suffer with rapid population growth; 2) human capital variables significantly affect the economy's growth potential although their effects are relatively lower than physical capital; and 3) health expenditures have a large impact effect while education expenditures have more enduring effects.

The model was also used to study the interaction among population change, women's role and status, and development. An enhancement of the role and status of women was defined by: 1) improvement in educational status; 2) delay in marriage; and 3) increase in labor force participation. The simulation results showed that all aspects have positive effects on socioeconomic development. However, the latter two had unintended adverse effects in the form of a decline in the real wage rate of women and an increase in the proportion of women who are unpaid family workers. This implies that improving the role and status of women via the last two modes should be accompanied by measures that would increase the labor absorptive capacity of the economy.

Economic development and the environment

This area received a great deal of interest in the 1990s and many studies are continuing. A good survey of the early empirical work is provided by Orbeta (1996). A summary of these studies is presented in the next section.

Many of the empirical studies on Philippine environment issues have made use of the pollution intensity estimates generated by the Environment and Natural Resources Accounting Project (ENRAP). The latter estimated air and water pollution by industry using emission factors and rapid assessment methodologies devised by the World Health Organization (WHO) and the US Environmental Protection Agency (EPA). ENRAP applied the WHO rapid assessment method mainly in estimating water pollution loads as well as in estimating process emissions. Meanwhile, the EPA emission factors were used to generate emission estimates from fuel combustion.

Eleven airborne and water pollutants are identified: particulate matter (PM), sulfur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOC), carbon monoxide (CO), biological oxygen demand

(BOD_5), suspended solids (SS), total dissolved solids (TDS), oil, nitrates, and phosphates. Total emission for pollutant *k*, $EMIS_k$ can be computed as follows:

$$EMIS_k = \sum_{i=1}^{n} \Psi_{ik} \cdot XD_i$$

where Ψ_{ik} is the effluent intensity of pollutant *k* in industry *i*, and XD_i is the domestic production of *i*. Methodologies vary in terms of generating the values of XD_i. A documentation of the pollution/environmental intensities is contained in Orbeta (1994).

A major shortcoming of these studies is that pollution does not enter utility, production functions or welfare criteria (Gunning and Keyzer 1995). As a result, it would be difficult to compare different scenarios (e.g., higher output cum higher pollution and lower output cum lower pollution).

Earlier research[17]

The study of Intal et al. (1994) applied a multi-industry partial equilibrium model called the Chunglee model. It linked industry outputs to changes in inter-industry effective rates of protection and changes in real exchange rate. In particular, the equation of interest in the simulation was specified as:

$$dQ_j = b_j Q_j [\frac{r_1}{r_0}\left(\frac{1+E_j^1}{1+E_j^0}\right) - 1]$$

where:

dQ_j	- change in output of industry *j*
b_j	- supply elasticity
r	- real exchange rate (*1* – posttrade reform; *0* – pretrade reform)
E_j	- effective protective rate

The model is static and assumes fixed input-output ratios and constant factor prices. As such, the model cannot capture the dynamic effects of investments that can arise from trade liberalization. In effect, the Chunglee model captures only the immediate effects of trade liberalization.

Data to capture intersectoral linkages were based on the 1983 input-output table. To compute for the environmental impact of trade policy change, pollution/environmental damage intensities were applied to changes in industry outputs. These pollution intensities were based on the aforementioned ENRAP estimates.

A trade policy change was simulated by applying a 50 percent across-the-board reduction in the effective protection rate with and without induced

[17]This part quotes heavily again from Orbeta's survey.

liberalization accompanied by currency depreciation led to an increase in output, it also raised the national average pollution-and-environmental damages intensity of production. This outcome was attributed to the reallocation of output toward logging, mining, and agriculture, which have large off-site environmental damages. Within manufacturing, there was a reallocation of output toward industries with higher pollution/environment intensities—food processing, wood products, and beverages.

The authors conjectured a possible trade-off between trade liberalization and currency depreciation, on the one hand—which results in improved allocation of resources to industries where the Philippines has comparative advantage—and environment protection, on the other. Given this potential conflict in policy objectives, two critical complementary measures to trade liberalization and currency depreciation must be addressed: 1) the internalization of environment damages when feasible; and 2) the encouragement of environment-friendly production technologies and product (or crop) choices.

Cruz and Repetto (1992) applied the updated version of Habito's model (PhilCGE) to assess the impact of trade reforms on the environment. However, the model did not account directly for the environmental consequences of production activities. The authors evaluated the environmental impact of economic policies by identifying sectors that were known to have significant effects and then gauging the direction of the environmental effects.

Their findings showed that the environmental impact of trade liberalization was generally adverse because of the increase in the following activities: erosion prone agriculture, logging, fishery, mining, and energy use. On the other hand, the impact of currency devaluation was uncertain because of the expansion in some sectors and decline in others. However, income distribution responded positively. Taken together, the impact on the environment was negative as the effects of trade liberalization outweighed those of the devaluation exercise. Based on these results, the authors advocated the following measures to accompany trade liberalization: more active promotion of labor-intensive industries together with strengthening efforts at environmental protection.

Another CGE-based application used a stylized model of a developing country with parameters derived from Philippine data (Coxhead and Jayasuriya 1994, 1995). The model specified two regions (lowland, upland), three goods (import competing manufactures, exportable tree crop, and nontraded food produced in both regions), and three inputs (capital, land, and labor). A key feature of the model is the delineation of alternative uses of the uplands to be either for annual food crops agriculture, which is erosive, or for less erosive perennial tree crops production. A corollary feature of the model is the link between relative food prices and land degradation: other things being equal, a higher relative food price increased the incentive to grow food rather than tree crops in the uplands. This response increased soil erosion.

The simulation results showed that trade liberalization could have positive environmental effects, at least in the case of soil erosion. It was shown that tariff reduction in lowland manufacturing increased the profitability of tree crop production in the uplands, causing increases in tree crop production (reducing upland food crop production), and consequently reducing land degradation.

Subsequent related studies can be found in Coxhead and Shively (1998), Coxhead (2000), and Coxhead et al. (2002).

Recent research: Inocencio et al. (2001)

Empirical work on the environment continues to emphasize model-based simulations. One such study focused on the impact of changes in the tax structure on the environment (Inocencio, et al. 2001).[18] An applied general equilibrium model was constructed which disaggregates the Philippine economy into 40 production sectors. Households were delineated by location (urban and rural), source of income (wages and salaries, entrepreneurial activities, and other sources), and expenditure pattern (proxied by classifying households as poor, middle income, and rich). The impact on the environment was simulated with the use of the ENRAP emission coefficients. A 40-sector social accounting matrix was constructed based on the 1994 I-O table of the NSCB. The parameters of the model were then calibrated to the 1994 SAM.

The disaggregation of the production sector allowed the authors to examine the effects of economic policies on specific industries while the disaggregation of households allowed the model to address equity issues. The model is neoclassical in nature and the standard Armington specification leads to the differentiation of domestic and foreign goods, which are then considered as imperfect substitutes.

Pigovian or pollution taxes were incorporated through the equation for net price or price of valued added, thus:

$$NP_i = (1-\tau_{1i})\cdot P_i - \sum_m \alpha_{mi}\cdot CP_m - \sum_n \alpha_i \cdot P_n - \sum_f \tau_{3f}\,\Psi_{fi}$$

where:

NP_i	- net price of sector/commodity i
P_i	- domestic price of commodity i
P_n	- price for nonimportable commodity n
CP_m	- composite price of commodity m
Ψ_{fi}	- emissions of pollutant f from the production of good i (in tons per million pesos)
τ_{1i}	- indirect tax rate on sector i

[18]This study was conducted under the auspices of Impacts of Macroeconomic Adjustment Policies on the Environment (IMAPE) project, a spin-off from the MIMAP project.

τ_{5f} - tax rate on emission *f* (pesos per ton)
α_{mi} - input-output coefficient
α_i - constant in the production function

The composite price is a weighted average of imports, IMP and domestic consumption A, as follows:

$$CP_m = \frac{DP_m \cdot IMP_m + P_m \cdot A_m}{IMP_m + A_m}$$

The domestic price of imports DP is determined as:

$$DP_m = ER \cdot WIP_m \cdot (1 + \tau_{4m})$$

where:

ER - nominal exchange rate
WIP_m - world price of importable good *m*
τ_{4m} - tariff on imported good *m*

The variable NP_i determines output in current prices, which can be used to calculate the return to fixed capital by subtracting the wage bill. The return to capital then forms part of net operating surplus, which is used to determine factor incomes, consumption and ultimately total savings. Total savings then determine investment to close the model.

Emission taxes form part of government revenue. With emission taxes affecting net price of firms and government revenue, a feedback mechanism from pollution emissions to output was established in the model. Other things held constant, greater emissions will lead to higher emission taxes, which will reduce the net price of output. The lower price would then lead to a fall in output of the affected sector and also reduce emissions.

The authors used the model to simulate three scenarios: a reduction in tariffs (lower τ_{4m}), a BOD_5 emission tax ($\tau_{5f} > 0$, with *f* being BOD_5), and a combination of these two policies. The last exercise sought to determine whether a "double dividend" is possible, i.e. the higher revenues from emission taxes compensate for the loss in tariff revenue at the same time keeping welfare at least constant. Other simulations were conducted but these are mainly sensitivity analyses to test the robustness of the results.

The results showed that a reduction in tariffs is welfare-improving in the aggregate but regressive. Welfare was measured by the equivalent variation, which is the amount of income needed to move from the base case to the new equilibrium position. A positive value for this indicator suggests a welfare improvement. Meanwhile, lower tariffs led to an increase in emission of all pollutants. Similar to the results of Intal, et al. the change in the tariff structure favored sectors with higher pollution intensities, e.g., fishery, forestry and other service sectors.

The pollution tax was slapped based on the amount of BOD5 emitted at a rate of P5,000 per ton ($.005 \cdot \Psi_{fi}$). This specification implies that more pollutive sectors will pay a higher tax. The imposition of a pollution tax resulted in a huge decline in overall welfare and in household incomes. However, this welfare loss was progressive. The positive side of the simulation results was the reduction in total emissions.

Using the emission tax to finance a tariff reduction policy partly realized the objective of a double dividend as there was an overall decline in pollution emissions and neutral effect on government revenues. However, the welfare effect was dominated by the impact of the emissions tax, leading to a substantial negative equivalent variation.

The authors cite a caveat on the emissions tax, pointing to the assumption that government has the ability to monitor emissions and enforce the tax. As in many developing countries, this assumption is likely to be unrealistic.

Recent research: Aldaba and Cororaton (2001)

A smaller version of the APEX model was constructed using only 34 sectors and has been called PCGEM or Philippine Computable General Equilibrium Model (Cororaton 2000). This model was used to study the impact of tariff reforms on pollution (Aldaba and Cororaton 2001). Like most other studies in this area, ENRAP pollution intensities were also applied but only seven pollutants were included. The effects of emission taxes were also examined to determine if they have a desirable effect. One difference of this study was the application of the World Bank Industrial Pollution Projection System (WB-IPPS) pollution intensities and comparing them with the ENRAP results. This constituted the impact of an improvement in technology.

The following modifications were introduced to the model in order to improve on the relevance of the simulation results. First, the model was made dynamic by allowing labor supply to grow, i.e., recursive dynamics. Variable capital was treated in the same manner. Meanwhile, supply of industry capital stock expanded with investment. These changes allowed the model to be simulated over a ten-year period (1990-1999).

The second modification was to add a variable for total emissions of pollutant k, $EMIS_k$ which was computed as:

$$EMIS_k = \sum_{i=1}^{n} \Psi_{ik} \cdot XD_i$$

where Ψ_{ik} is the effluent intensity of pollutant *k* in industry *i*, and XD_i is the domestic production of commodity *i*.

Emission taxes were added to indirect taxes. This is equivalent to increasing the variable τ_{1i} in the Inocencio et al. model as follows:

$$INDTAX_i = \tau_{1i} + EMTX_i$$

where INDTAX is the total indirect tax and EMTX is the emission 2001 tax. The tax was in effect applied to all types of pollutants—Inocencio et al. only considered BOD_5—but was also scaled according to the level of industry emission. The authors took into account the fact that total output of a specific industry varies as a result of the changes in policy, and so would the contribution of that industry to total pollution. Hence the emission tax was computed as:

$$EMTX_i = \tau \cdot \left(pol_i^1 \Big/ \sum_i pol_i^0 \right)$$

In this equation τ is an across-the-board tax, pol_i^1 is the pollution intensity of industry i during the simulation period and pol_i^0 is the pollution intensity in the base period.

The results showed that a reduction in tariffs was favorable in terms of both household welfare and distribution. Welfare was also measured by the equivalent variation. However, the impact on pollution was mixed but the overall change in the level of emission for all pollutants seemed to be very small.

The imposition of an output tax on emissions was counterproductive, as it not only wiped out the gains from the tariff reform program, it also increased the emission of some pollutants. The latter arose from the reallocative effects of the tax on emissions. Similar to the result of Inocencio et al. the double dividend did not materialize.

The results using the WB-IPPS pollution intensities yielded substantially lower emission levels. Moreover, the difference widened for all pollutants as the tariff program progressed. This result implies that improvement in production technology is likely a major factor that can check the problem of pollution in the process of industrialization.

Recent research: application with the APEX model

While the Philippine government has taken direct steps to address environmental concerns, there may be other programs and policy changes that may have potentially large environmental effects. This is the main reason for conducting all these simulation runs and the same rationale for a recent exercise using the APEX model (Coxhead and Jayasuriya 2002). The focus was also on trade liberalization.

Like the previous two models, APEX does not contain explicit environmental information. However, unlike the other models, the authors of this study applied AHTI (or acute human toxicity index) emissions intensity data. The results broadly show that trade liberalization reduced activity in manufacturing sectors, which are mainly import competing and receive the highest initial protection, and increased it in food processing and in primary industries, including forestry and mining. Within manufacturing, where there is a general correspondence between capital intensity, protection rates, and emissions intensity, some heavily emissions-intensive sectors contracted. Conversely, many labor-intensive export oriented industries, which expanded as a result of liberalization, are not especially emissions-intensive; the net result was argued to be a composition effect that is beneficial to the environment.

Aggregate agriculture output changed little, although output did exhibit considerable regional and sectoral variation. Overall, the authors concluded that trade policy reform induces composition effects that are consistent with increased environmental protection in lowland and upland/ forestry ecosystems, provided institutional failure (such as open access in forestry) are not severe. Meanwhile, macroeconomic and distributional results of the trade policy simulation showed the reforms to have a very small positive effect on aggregate welfare, measured as the weighted sum of real household consumption expenditures.

5
Conclusion

The major question that arises from this survey is: What is the most appropriate model to use?

The traditional answer would have focused on the objective of the user. If forecasts are required, then MEMs would be the more appropriate tool. On the other hand, if the purpose is to monitor the impact on social outcomes, then CGE models would be more suitable. However, nowadays, there is a gray area between these two types of models.

CGE models increasingly use econometric estimates for calibration (e.g., the APEX model) and dynamics can readily be incorporated. These features enhance their forecasting ability. Meanwhile, MEMs can be applied to monitor social outcomes via the simulation approach so long as they generate the appropriate linking variables (e.g., factor incomes and prices). The problem of inadequate theoretical underpinnings has also been addressed, particularly through the DSGE approach. The latter methodology actually shows how econometrics and calibration can be blended.

The issue becomes slightly more complicated in the event that two or more models that address the same policy issue will yield different results.[19] Of course, one can argue that the structures of the models are different but then the question becomes: What is the appropriate structure?

Judgment of the user becomes very important in this situation. A useful step would be to establish an agency or unit whose responsibility would be to consolidate all the relevant model results into a coherent story. Otherwise, inter-agency meetings to thresh out policy matters could deteriorate into endless arguments, all beginning with the statement: "According to our model . . . "

Finally, economic modelers must give pause and study carefully the implications of the aggregation problem, which has recently experienced a revival (Felipe and Fisher 2002). The basic contention is that the macro production function is a fictitious entity and the concept cannot be used both analytically and empirically. If indeed, the argument is correct, applied economists would have a great deal more to worry about than closure and convergence.

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[19]The situation becomes even more difficult when the models are both CGE with the same underlying theory, e.g., neoclassical.

Appendix 1. Comparison of selected macroeconomic models

1A. Comparison in terms of model response to critique of Cowles Commission approach

PIDS-NEDA Model (1993)	Quarterly Model	Annual Model with Social	Ateneo MFM
* Well specified production sector and strong links to expenditure sector	* Use of Engle-Granger two-step estimation procedure * Specification of forward-looking inflationary expectations * Application of extensive testing of each behavioral equation	* Use of Engle-Granger two-step estimation procedure * Specification of forward looking inflationary expectations	* Core of model is production sector, which has firm theoretical foundations * Specification of forward-looking inflationary expectations

***Comparisons shown in 1B-1E are obtained from Reyes and Constantino (2000) except for description of Ateneo MFM. Details of NEDA Quarterly Model in 1B describing output determination have been modified based on the latest version.

Appendix 1B. Comparisons in terms of models' treatment of the real sector

PIDS-NEDA Model (1993)	Quarterly Model	Annual Model with Social	Ateneo MFM
Output Determination/Closure of the Model			
* GDP is sum of production components * Statistical discrepancy is balancing variable to equatedemand and supply	* GDP is sum of production components * Statistical discrepancy is balancing variable but does not appear in expenditure identity.	* Minimum of demand-determined GDP and supply-determined GDP	* GDP is sum of expenditure components * GDP sans net exports feeds into first stage of production process
Sectoral Gross Value-Added (Production Side)			
* Estimates supply and demand equations * Supply and demand equations for agri subsectors; prices are estimated by equating demand and supply * Demand equations for non-agri subsectors mainly a function of prices, investment and consumption demand * Prices for non-agri are a function of WPI and CPI	* Cobb-Douglas production function for agriculture * Computes for potential output (non-agricultural) and capacity utilization rate (which affects employment, wages, prices)	* Agri is exogenous· * Cobb-Douglas production for industry- services combined * Share of Industry to I-S total is modeled * Share of Services is residual	* GDP is not disaggregated into production sectors * Production sector follows a two-stage process from which equilibrium values of selected variables are obtained

Appendix 1B (cont'd.)

PIDS-NEDA Model (1993)	Quarterly Model	Annual Model with Social	Ateneo MFM
	Expenditure Components		
* Government investment exogenous; all others endogenous * With "crowding-in"effect of government construction spending * Exports and imports determined under BOP/external block	* Government investment exogenous; all others endogenous * Private consumption is dis-aggregated into food and nonfood * Exports determined by world activity and prices	* Government investment and consumption exogenous; all others endogenous * Exports and imports dependent on world trade, exchange rate, world prices	* Fixed investment is based on Tobin's q model * Government expenditure components are exogenous except for interest payments
	Prices		
* Wholesale price index a function of wage, import price, capital stock growth and liquidity ratio to GNP * Implicit price indices for GNP a function of WPI * CPI a function of GDP price deflator–weighted average of sectoral prices	* Sectoral prices are determined by capacity utilization, money supply, wages, exchange rate, and import prices * CPI is a weighted average of prices of domestic and imported goods	* GDP price deflator is related to wages, exchange rate, import price, money supply and labor productivity * CPI is determined from GDP deflator and dollar import price index	* Price of domestic output *py* determined from production sector * CPI is a function of *py* * PGDP is a weighted average of *py* import prices, and export prices

Appendix 1C. Comparison in terms of their treatment of the fiscal sector

PIDS-NEDA Model (1993)	Quarterly Model	Annual Model with Social	Ateneo MFM
* Tax revenues are determined by GNP (for direct taxes) and by imports (for trade taxes) * Government expenditures are exogenous * Budget deficit derived * Highlights 3 means of deficit financing (treated exogenously) - Monetization of public debt/MA's credit to national government – TL - External financing reflects additional resources - Open market borrowing affects interest rate * Incorporates role of public corporate sector - Models capital expenditure of public corporations and NAPOCOR - Enters real sector through supply of crops and electricity, gas and water	* Tax revenues linked to real activity, incomes and trade * Nontax revenues are exogenous * Government expenditures are endogenous * Distinguishes three modes of deficit financing - Foreign borrowings - Domestic borrowings - Changes in financial cash balances * Increase in deficit leads to increase in domestic borrowings which in turn leads to increase in interest rates	* Tax revenues as a function of GNP and dummies * Nontax revenues are exogenous * Most government expenditures are exogenous - Sum of COE, CO, interest payments and NL - Sum of sectoral expenditures * Real educational expense is a function of real revenues and past value	* Identities for indirect, import and income taxes in the form of tax base tax rate * Fiscal deficit does not feed into real economy * Financing of deficit is essentially exogenously determined, based on a given ratio of domestic to external borrowing * Composition of deficit financing does not affect real economy since money supply is exogenous

Appendix 1D. Comparison in terms of their treatment of the monetary sector

PIDS-NEDA Model (1993)	Quarterly Model	Annual Model with Social	Ateneo MFM
* Determines monetary aggregates thru standard equations * Broad money (TL) * Money Supply (MS) TL and MS are money demand equations determined by GNP and 91-day T-bill rate * Affected by means of financing of budget deficit * TL indirectly affected by monetization of public debt T-bill rate affected by inflation and deficit financed through domestic borrowings	* Determines money supply in terms of NFA and NDA * NFA a function of BOP * NDA a function of BSP's credit to public and private sectors * Currency-to-deposit ratio, money multiplier and interest rates are endogenously determined * Interest rate is related to GNP, MS, T-bill issuance ratio to MS and inflation	* Determines MS to from money multiplier and base money * Money multiplier is related to required reserve, currency deposit ratio, and time deposit ratio, and time * Reserve money is sum of BSP's NFA and NDA, both endogenously derived * Interest rate is a function of GNP, inflation, and money supply	* Assumes money market clearing * Money supply is exogenous, interest rate equation is estimated reflecting inverted demand for money

Appendix 1E. Comparisons in terms of models' treatment of the external sector

PIDS-NEDA Model (1993)	Quarterly Model	Annual Model with Social	Ateneo MFM
* The following are endogenously determined * Exports semiconductors, garments, other manufacturers, agri, others) * Imports (total, fuel) * Exports and imports of nonfactor services * Current account BOP (capital flows are exogenous) * Exchange rate (a function of interest rate differential, and inflows and outflows of foreign exchange loans and trade)	* The following are endogenously determined * Trade balance (exports and imports under real sector block) * Net factor services * Foreign investments (portfolio and direct) * Exchange rate (dependent on interest rate differentials)	* The following are endogenously determined * Current account balance (dis-aggregated exports and imports are determined under the real sector block) * Exchange rate (a function of inflation differential, base money growth rate, gross international reserves (months equivalent of imports), BOP/GNP ratio)	* Real exports and imports are determined by dyamic structure involving lagged equilibrium values and lagged actual values * Converted to dollar terms and form part of BOP identity * Only other endogeneous terms in BOP are government and private sector interest payments on external debt * BOP does not feed into real economy, since money supply is exogoneous * Exchange rate is determined via interest parity condition

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This paper surveys the development of macroeconometric and CGE models in the Philippines during the period 1990-2002, primarily in terms of their structure and applications. Many of the recent developments in macroeconometric modeling have been incorporated in Philippine models. However, Philippine CGE models have hardly progressed beyond the standard neoclassical framework. Over time, there has been convergence in these two types of quantitative models: CGE models have increasingly used econometric estimates obtained from time-series data while macroeconometric models have been applied to monitor social outcomes like poverty and income distribution. These quantitative tools have become an integral part of policy analysis in the Philippines.

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