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A GENERAL EQUILIBRIUM MODEL FOR PHILIPPINE AGRICULTURAL POLICY ANALYSIS

Cielito F. Habito

I. INTRODUCTION

The current economic difficulties of the Philippines have led to a much wider recognition of the crucial role of the agricultural sector in the country's development. As a result, the government's agricultural policies are undergoing much greater scrutiny both within and outside the government. Much of the groundwork for agricultural policy analysis has been laid with studies undertaken in recent years, spearheaded by the work of David (1983) and colleagues. More recently, the Agricultural Policy Working Group at the University of the Philippines at Los Baños has examined policy issues in key agricultural sectors of the economy, culminating in a set of papers and a workshop held in May 1985. These analyses have provided a starting point for what will hopefully be sustained and more in-depth analyses of policy options for Philippine agriculture.

Developments in applied quantitative analysis have made it possible to undertake policy analyses within a general equilibrium framework. Whereas past analyses tended to be partial equilibrium in nature (i.e., taking specific markets in isolation), methods are now available for examining intermarket linkages which can be equally important in determining the overall impacts of specific policy changes. Computable general equilibrium (CGE) models have become a popular tool for examining various types of economic policies in both developed and developing countries alike.[1] While their construction involves a significant amount of investment in time and effort (particularly in

Assistant Professor, College of Development Economics and Management, University of the Philippines at Los Baños.

1. A good survey of the literature is provided by Shoven and Whalley (1980).

assembling a suitable data set), a moderately disaggregated model, once constructed, can lend itself to a wide range of policy analyses with relatively little modification.

The use of CGE models for simulating and analyzing economic policies in the Philippines is relatively new. Two Philippine CGE models are known to be in existence, and these have been constructed for different purposes: one for an evaluation of Philippine tax policies by the author (Habito 1984) and one to examine trade policies (Clarete 1984). A third model by Romeo Bautista is currently under development, apparently intended for an assessment of Philippine food policy issues.

Work is currently under way to update, modify and adapt the Habito (1984) model for use in the analysis of Philippine agricultural policies. This paper outlines the general features of the original model, and describes the modifications introduced to make it more suitable for agricultural policy analysis. The next section outlines the structure of the model, while section 3 describes solution procedures for computing equilibrium prices with the model. The paper concludes with some remarks about limitations of, and further modifications intended for, the model.

2. MODEL STRUCTURE

The original version of the Philippine CGE model has 18 production sectors, 11 household groups, and three primary factors of production (capital, rural labor and urban labor). The current version has been reduced to 14 production sectors, seven of them being specific agricultural sectors. Household groups have also been reduced to 10 and reflect a greater disaggregation of higher income groups than the original version. Table 1 describes the goods under the various sectors and the household group classifications.

The other major components of the model are the government and the foreign sector. The government derives its income from direct and indirect taxes, public enterprises, and direct government transfers from abroad, and spends it on the products of the producing sectors with fixed expenditure proportions. Foreign transactions are based on a fixed exchange rate, which best approximates the "managed float" exchange rate regime that has prevailed in the Philippines in the past decade. Imports are treated as imperfect substitutes for domestic goods; products of each sector are therefore treated as composites of

TABLE 1
GOODS AND HOUSEHOLD DEFINITIONS

PRODUCTION SECTORS (18-SECTOR VERSION)

1. Agriculture and fisheries
2. Forestry and logging
3. Mining
4. Processed food and tobacco
5. Textiles and apparel
6. Wood and rubber products
7. Paper and printing/publishing
8. Chemical products
9. Petroleum refining
10. Cement and nonmetallic mineral products
11. Metals, machinery and misc. manufactures
12. Transport equipment
13. Electricity, gas and water
14. Construction and real estate
15. Trade
16. Banking, finance and insurance
17. Transportation, storage and communication
18. Services

PRODUCTION SECTORS (14-SECTOR VERSION)

1. Palay	8. Processed food
2. Corn	9. Mining
3. Coconut	10. Nonfood manufacturing
4. Sugarcane	11. Transport
5. Fruits and other crops	12. Services
6. Livestock and poultry	13. Energy
7. Fishery and forestry	14. Fertilizer

HOUSEHOLDS (BY INCOME)

Original	Modified
1. UNDER P1,000	1. UNDER P2,000
2. P1,000-P1,999	2. P2,000-P4,999
3. P2,000-P2,999	3. P5,000-P7,999
4. P3,000-P3,999	4. P8,000-P9,999
5. P4,000-P4,999	5. P10,000-P14,999
6. P5,000-P5,999	6. P15,000-P19,999
7. P6,000-P7,999	7. P20,000-P29,999
8. P8,000-P9,999	8. P30,000-P39,999
9. P10,000-P14,999	9. P40,000-P49,999
10. P15,000-P19,999	10. P50,000-AND ABOVE
11. OVER P20,000	

the two, defined by a trade aggregation function. Figure 1 provides a schematic representation of the model.

The benchmark year for the original version was 1974, chosen because it was the latest year for which a complete data set on production, consumption and taxes had been available. It has now been possible to update the benchmark year to 1978. Production-side data have been derived from the 1978 Inter-Industry (Input-Output) Accounts, the National Income Accounts Series, and the 1978 Annual Survey of Establishments. Consumption data came from the Family Income and Expenditures Survey of 1975, while government income and expenditures data have been derived from the National Income Accounts Series. Although the analysis is essentially static, the model has been run for three forward periods (two years apart) aside from the benchmark year to determine the medium-term effects of policy changes.

The remainder of this section outlines the mathematical structure of the model.

2.1 *Production*

$$X_j = \min(A_j, V_j) \qquad i = 1, \ldots, N \tag{2.1}$$

X_i = output of good i

A_i = intermediate inputs

V_i = value added in sector i.

In turn,

$$A_i = \min_j \left(\frac{x_{ji}}{a_{ji}}\right) = i, j = 1, \ldots, N \tag{2.1a}$$

$$V_i = \mu_i \left[\delta_i L_i^{-\rho_i} + (1 - \delta_i) K_i^{-\rho_i}\right]^{1/\rho i} \tag{2.1b}$$

$$i = 1, \ldots, N$$

L_i, K_i = labor and capital use in sector i, respectively.

L_i is, in turn, a CES aggregation of rural and urban labor:

$$L_i = C_i[\gamma_i L_{ri}^{-\alpha i} + (1 - \gamma_i) L_{ui}^{-\alpha i}]^{1/\alpha i} \tag{2.1c}$$

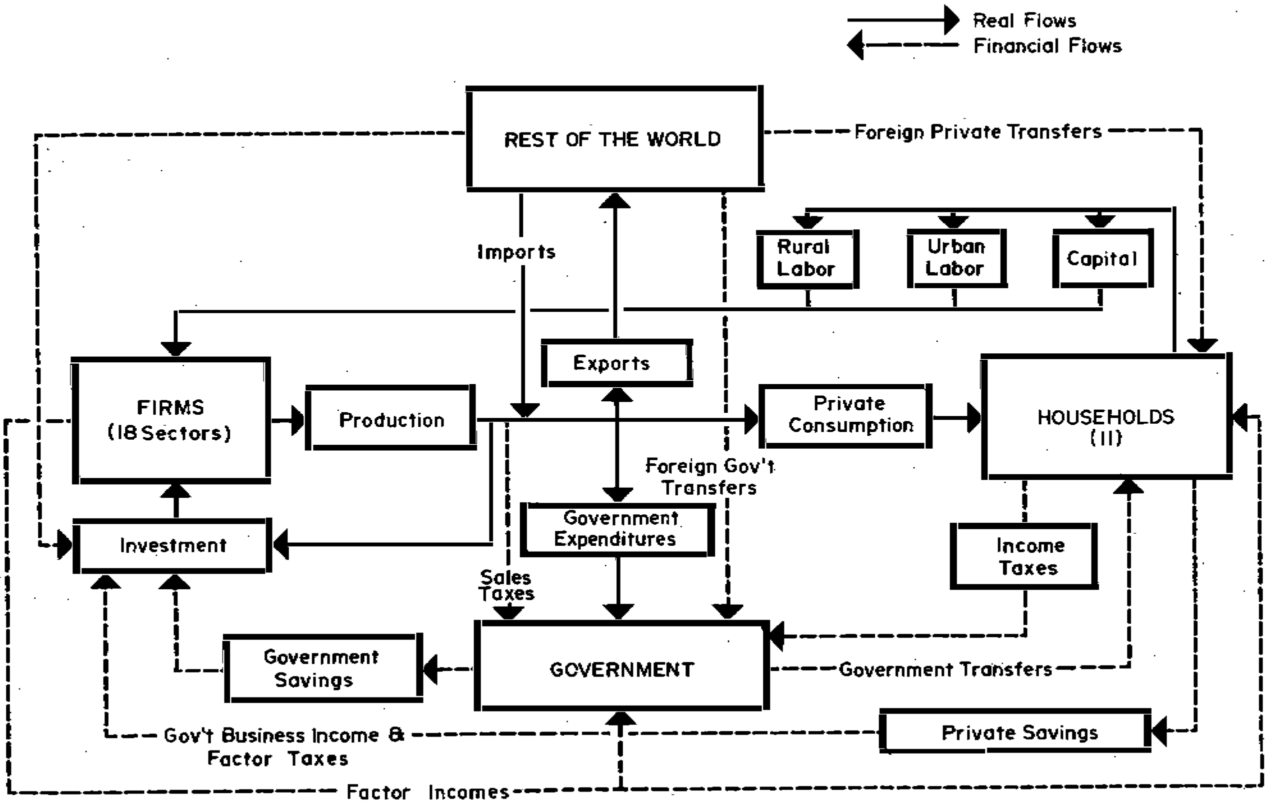

FIGURE 1

SCHEMATIC DIAGRAM OF THE CGE MODEL

$i = 1, \ldots, N$

L_{ri} = rural labor employed in sector i

L_{ui} = urban labor emloyed in sector i.

This formula is highly restrictive in that it does not permit substitution among intermediate inputs, or between intermediate and primary inputs. One can improve this specification by allowing the intermediate input coefficients to vary in response to changes in prices. This method has been demonstrated by Goulder (1982), and requires estimates of average cost or profit functions using flexible functional forms like the translog or normalized quadratic functions. From Shephard-Hotelling's lemma, the (variable) input-output coefficient can be computed as the first derivative of the average cost or profit function with respect to the input price. In this way, the input coefficients can be made price-responsive, thereby permitting a more flexible treatment of input substitution in the model. Estimates of cost and/or profit functions to be undertaken by colleagues in this research project (see articles by Evenson and Bantilan, this Journal issue) will be used to implement this specification of the model's production segment.

2.2 *Prices*

$$PM_i = PW_i \; (1 + t_{mi}) \; ER \qquad i = 1, \ldots, N \qquad (2.2)$$

where PM_i = import prices, in pesos
PW_i = world price of good i, in dollars
t_{mi} = tariff rate on good i
ER = exchange rate, pesos/dollar

$$PWE_i = \frac{PD_i}{(1 + t_{ei}) \; ER} \qquad i = 1, \ldots, N \qquad (2.3)$$

PWE_i = export price of good i, dollars
PD_i = domestic price of good i, in pesos
t_{ei} = export subsidy rate (negative if tax)

With this definition of prices, the small country assumption is made on the imports side, but not on the exports side. However, the Armington assumption is invoked for imports, i.e, imported goods are differentiated from their domestic counterparts. Hence, domestic price for importables need not equal the world price. Locally purchased goods are defined as a composite of imports and domestic goods. This composite good is defined through a CES trade aggregation function, leading to the following expression for the "composite" domestic price, P_i:

$$Pi = \frac{PD_i + PM_i \ . \ M_i / D_i}{f_i (M_i / D_i, 1)} \qquad i = 1, \ldots, N \qquad (2.4)$$

where M_i = imports of good i, in pesos
D_i = domestic demand for good i, in pesos
f_i = CES trade aggregation function

More precisely, given f_i (.) as

$$X_i = A_i \, [\delta_i M_i^{P-pi} + (1-\delta_i) \, D_i^{-pi}]^{1/pi}$$

then the cost function gives

$$P_i = \frac{1}{\beta_i} [\, \delta_i^{\,\sigma i} PM_i^{\,(1-\sigma i)} + (1-\delta_i)^{\sigma i} PD_i^{\,(1-\sigma i)}]^{\,1/(1-\sigma i)}]$$

$$i = 1, \ldots, N \qquad (2.4a)$$

The net or value-added price PN is defined as

$$PN_i = PD_i - \sum_j p_j a_{ji} - t_{di} PD_i \qquad (2.5)$$

$$i = 1, \ldots, N$$

where t_{di} = indirect tax rate
a_{ji} = input-output coefficient

The numeraire is defined through a weighted general price index:

$$\sum_i \Omega_i \, P_i = \bar{P} \qquad (2.6)$$

Ω_i = price index weights ($\Sigma \ \Omega_i = 1$)
P = price level

2.3 *Incomes*

The institutional income of labor (Y_{Lj}, $j = r, u$) is the sum of wage payments in all sectors net of labor factor taxes, plus a fixed share of exogenous personal transfers from abroad:

$$Y_{Lj} = \sum_{i} W_j \cdot L_{ji} (1 - t_j) + s_{Lj} PT \qquad (2.7)$$

$$i = 1, \ldots, N; j = r, u$$

where W_j = average wage rate for labor type j
t_j = direct tax on income of labor category j
s_{Lj} = labor type j's share of personal transfers from abroad
PT = exogenous personal transfers from abroad

Capital factor income is computed as a residual of value added after deducting all labor payments, and netting out capital factor taxes. Part of this income accrues to the government, through government corporations. Deducting this government share and adding capital's share of personal transfers from abroad yields the (private) institutional income of capital (Y_K):

$$Y_K = \sum_{i} (PN_i X_i - \sum_{j} w_j L_{ji}) \cdot (1 - g)(1 - t_{Ki}) \qquad (2.8)$$

$$+ s_K PT$$

$$i = 1, \ldots, N; j = r, u$$

where t_{Ki} = direct tax on capital income in sector i
s_K = capital's share of personal transfers from abroad
g = government share of capital factor income

Institutional incomes are, in turn, allocated to the eleven household groups according to a fixed allocation matrix F, where each element f_{lk} denotes the proportion of the income of factor 1 ($1 = L_r$, L_u, K) that accrues to household K. In addition, households receive net remittances from abroad, based on fixed shares of total remittances for each household group. Households also receive transfers from the government. Thus, household incomes (Y_k) are defined as follows:

$$Y_k = f_{Lr,k} \cdot Y_{Lr} + f_{Lu,k} \cdot Y_{Lu} + f_{Kk} \cdot Y_K + r_k \cdot R + TG_k \qquad (2.9)$$

$$k = 1, \ldots, K$$

where r_K = household K's share of total remittances

TG_k = government transfers to household group k

Government income is derived from various tax revenues, as well as foreign transfers and government business income:

$$\begin{aligned} Y_G = & \sum_i \sum_j t_j W_j L_{ji} + \sum_i t_{Ki} (PN_i X_i - \sum_j W_j L_{ji}) \\ & + \sum_k t_k \cdot Y_k + \sum_i t_{mi} PW_i ER \cdot M_i \\ & - \sum_i t_{ei} PWE_i ER \cdot E_i \\ & + t_{di} X_i^S PD_i + \overline{GT} \cdot ER + g \cdot Y'_K \end{aligned} \qquad (2.10)$$

$$i = 1, \ldots, N; \; j = r, u; \; K = 1, \ldots, K$$

where $\overline{GT}$ = net government transfer receipts from abroad (set exogenously)

Y'_K = capital factor income

2.4 *Foreign Trade*

The demand for exports is assumed to be a constant elasticity function of export price:

$$E_i = \theta_i \left(\frac{\pi_i}{PWE_i} \right)^{\eta_i} \qquad i = 1, \ldots, N \qquad (2.11)$$

where π_i = the average world price

η_i = the export demand elasticity

θ_i = a constant term which gives the demand for Philippine export product i when $P_w E = \pi_i$.

This formulation drops the small country assumption on the export side, and permits the country's export price PWE to differ from the average world price π. Thus, export demand depends on how PWE differs from π.

Following Dervis et al. (1982), the export supply function is specified as an asymmetric logistic function, as follows (sector subscripts omitted):

$$\frac{E}{X} = \frac{\bar{A}_1}{1 + \exp\left[B_1 (r - \bar{r})\right]} + \bar{C}_1 \qquad \text{for } r \geq \bar{r}$$

$$= \frac{\bar{A}_2}{1 + \exp\left[B_2 (r - \bar{r})\right]} + C_2 \quad \text{for } r \leq \bar{r} \qquad (2.12)$$

(N equations)

$\bar{r}$ = PE/PD for the benchmark year
r = PE/PD for the current year
PE = $PWE\ (1 + t_{ei})\ ER$
A, B and C are function parameters.

Here, *PD* is the price that will clear the domestic market, while *PE* will be the price to clear the export market.

Because domestically-purchased goods are a composite of domestic and imported goods aggregated via a CES function, the demand for imports M_i and domestic goods D_i become derived demands based on the demand for the composite good. The purchaser's choice of the ratio between imported and domestic goods is analogous to the choice of input ratios given a CES production function. From the first order conditions for cost minimization, we get the demand for imports as:

$$M_i = \left(\frac{\delta i}{1 - \delta_i}\right)^{\sigma_i} \cdot \left(\frac{PD_i}{PM_i}\right)^{\sigma_i} D_i \qquad i = 1, \ldots, N \qquad (2.13)$$

where δ_i = share parameter in trade aggregation function
σ_i = trade substitution elasticity

Using the small country assumption, the supply of imports is perfectly elastic at the world price.

The balance of payments condition is stated as follows:

$$\sum_i \overline{PW}_i M_i - \sum_i PWE_i \cdot E_i - \overline{FKAP} = 0 \qquad (2.14)$$

where M_i and E_i are imports and exports, respectively, and FKAP stands for the exogenous net foreign capital inflows.

2.5 *Investment*

Total investment is equal to total savings at equilibrium, i.e.

$$TI = \sum_k \overline{S}_k Y_k + \overline{S}_G Y_G \quad k = 1, \ldots, K \qquad (2.15)$$

where $\overline{S}_k$ and $\overline{S}_G$ are the fixed saving rates of households and government, respectively. Total investment can be disaggregated by sector of destination as follows:

$$I_i = \theta_i \cdot TI \quad i = 1, \ldots, N \qquad (2.16)$$

With a capital coefficients matrix Z, we can also derive investment by sector of origin:

$$Z_i = \sum z_{ij} \cdot I_j \quad i = 1, \ldots, N \qquad (2.17)$$

where z_{ij} is the capital coefficient giving the proportion of good i embodied in one unit of capital good j. Hence, Z_i gives the investment demand for the product of sector i.

2.6 *Consumption Demands*

Total consumption demand is the sum of household and government demands:

$$C_i = \sum_k C_{ik} + C_{gi} \quad i = 1, \ldots, N \qquad (2.18)$$

where C_{ik} is the consumption of good i by household group k, and C_{gi} is the consumption of good i by government.

$$C_{gi} = \overline{g}_i \cdot C_G \quad i = 1, \ldots, N \qquad (2.19)$$

where g_i is the fixed government expenditure share on good i.

Household demands are defined with the Stone-Geary linear expenditure system (LES):

$$C_{ij} = \gamma_{ij} + \frac{\beta_{ij}}{P_i} (Y_j - \sum_k P_k \gamma_k) \qquad (2.20)$$

$$i = 1, \ldots, N; \quad k = 1, \ldots, K$$

where γ_{ij} is the subsistence minimum, and β_{ij} gives the marginal budget shares. Households are assumed to have a fixed savings rate out of income.

The current implementation of the model will attempt an incorporation of cross-price demand elasticities by employing more flexible consumption systems. Parameters for consumption systems using flexible functional forms are being estimated directly as part of this general research project (see Quisumbing, this Journal issue).

2.7 *Intermediate Demand*

The intermediate demand for the product of sector i is given as follows:

$$V_i = \sum_i a_{ji} X_j \qquad i = 1, \ldots, N \qquad (2.21)$$

2.8 *Labor Market Equilibrium*

At equilibrium, the marginal revenue product equals the wage:

$$PN_i \frac{\delta X_i}{\delta L_{ji}} = W_j \qquad i = 1, \ldots, N; \; j = 1,2 \qquad (2.22)$$

Total demand for labor of category j is the sum of respective demands in each sector:

$$L_j^D = \sum_i^N L_{ji} \qquad j = r, u \qquad (2.23)$$

Labor market clearing requires that:

$$L_j^D - \overline{L}_j^S = 0 \qquad j = r, u \tag{2.24}$$

2.9 *Product Market Equilibrium*

The domestic demand for good *i* is the sum of domestic investment, consumption and intermediate demands:

$$D_i = d_i \cdot (Z_i + C_i + V_i) \qquad i = 1, \ldots, N \tag{2.25}$$

where $d_i = \dfrac{1}{f_i\,(M_i \,/\, D_i, 1)}$ is the domestic use ratio.

Total demand is given by the sum of total domestic demand and export demand:

$$X_i^D = D_i + E_i \qquad i = 1, \ldots, N \tag{2.26}$$

Finally, product market clearing requires that:

$$X_i^D - X_i^S = 0 \qquad i = 1, \ldots, N \tag{2.27}$$

3. COMPUTATIONAL PROCEDURES

3.1 Solution Procedure

There have been two general approaches or "solution procedures" employed in the implementation of computable general equilibrium models. The first, exemplified by the Shoven and Whalley model for the U.S., reduces the problem to one of clearing the factor markets and deriving all product prices from the equilibrium factor prices. Here, primary inputs are assumed to be mobile across all sectors, leading to equal wages and capital rentals across all producing sectors. Given perfect competition and constant returns to scale, product prices are completely determined by the factor prices. Thus, it is only necessary to compute excess demands in factor markets; the product markets are substituted out in the solution. The solution procedure can be summarized as follows. Given an initial guess at factor prices, one can use the cost functions of each producing sector to determine the competitive product prices. The given supplies of factors (either exogenous or a function of the factor prices) determine factor incomes, which in turn determine household incomes. With product prices and household incomes known, product demands are determined. Setting sectoral production equal to demands, the respective production functions in turn determine factor demands. The problem is solved if factor demands equal factor supplies (i.e., excess demands are zero); otherwise, the solution algorithm tries a new set of factor prices. This "factor market approach" significantly reduces the dimensionality of the problem and lends itself to convenient fixe-point solution algorithms, like those devised by Scarf (1977) and Merrill (1971).

However, this approach becomes difficult when product markets cannot be simply substituted out, as in cases where constant returns to scale do not hold because of factor immobility. This is the case in our current model of the Philippine economy, where each sector's capital stock is held fixed within a given period. Thus, one cannot simply substitute product markets out from the factor market, because cost (and hence prices) will not be independent of the level of production. One possible way out would be to define as many categories of capital as there are sectors, with each capital type being used exclusively by the respective sector. However, this significantly increases the dimensionality of the problem, adding as many prices to compute as there are sectors, making it no more efficient than the "product market" approach described below.

The alternative approach, and the one that has been employed here, involves computing for excess demands in both product and factor markets. Here, one begins by defining an initial guess at product prices. One then looks at the labor market(s), and starts with a guess at wages of each labor category. From this, one can derive sectoral supplies and hence labor demands, using the production functions and the assumption of profit maximization. Given labor supplies (either exogenously set or defined as a function of wage), one can compute for excess labor demands. If these demands are zero, the labor market has been solved; otherwise, the algorithm tries a new guess at the wages. Given the (tentative) equilibrium wages and the specified product prices, it is possible to compute for all incomes. These, in turn, determine product demands, given the demand functions of households, the government, and the foreign sector. With product supplies already defined, excess product demands can be computed. The solution has been reached if these are zero; otherwise, the algorithm repeats the whole process with a new guess at product prices. This approach is illustrated schematically in Figure 2.

Fixed-point algorithms become costly in cases where there is a relatively large number of prices to compute, as is necessitated where constant returns to scale and perfect factor mobility are not imposed. Thus, the "product market approach" has commonly been implemented using the Newton-Raphson algorithm or variants of it, which tend to be more efficient in this situation. The algorithm used for our particular model's implementation is described in the next section.

3.2 Solution Algorithm

There are two general types of algorithms employed for solving multisectoral general equilibrium models: those based on fixed-point theorems, and those making use of a tatonnement process. The elegant algorithm devised by Scarf (1977) and its variant by Merrill (1971) exemplify the former, and have been used by Shoven and Whalley in their U.S. model, among others. This has the advantage of guaranteed convergence; however, its computational cost rises quickly with the number of equilibrium prices that must be computed. It has proven to be the ideal algorithm to employ with the factor market approach described above, where the dimensionality of the problem reduces to a usually small number of primary factors.

The World Bank model which has been adapted to the Philippines for this study makes use of an algorithm devised by Powell (1970) which is essentially a variant of the Newton-Raphson hill-climbing method. The algorithm makes use of information on the Jacobian of the system of excess demand functions to determine the direction and step length of the tatonnement process. The problem can be expressed as a search for the solution of a system of nonlinear equations of the form $f_i\ (P_1, \ldots, P_n)$, or in matrix notation:

$$f\ (P) = 0 \tag{3.1}$$

The tatonnement procedure can be written as:

$$P\ (t+1) = P^{(t)} + \alpha^{(t)}\ d^{(t)} \tag{3.2}$$

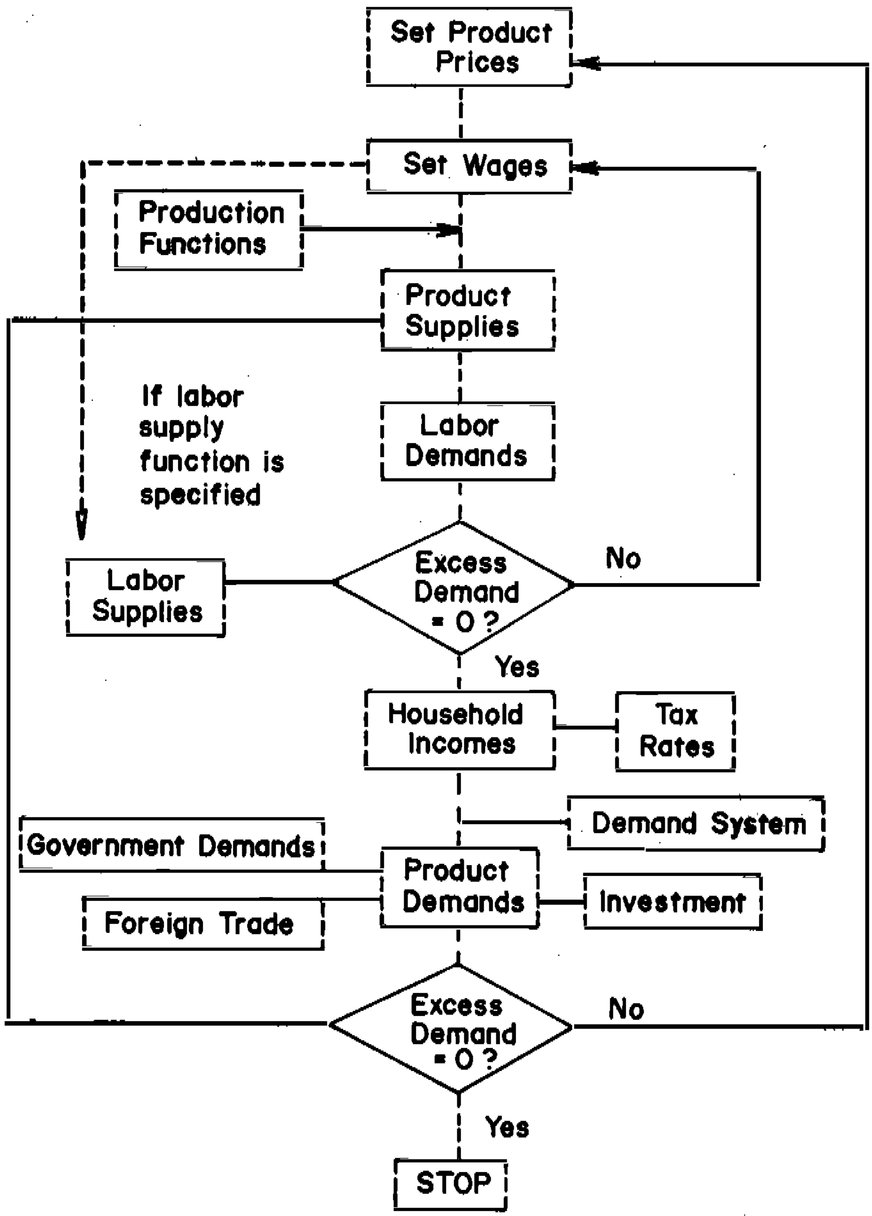

FIGURE 2
SOLUTION PROCEDURE FOR PRODUCT MARKET APPROACH

where t denotes the iteration, $d^{(t)}$ is a direction vector and $\alpha^{(t)}$ is a scalar giving the size of the step to be taken in the direction $d^{(t)}$. The Newton-Raphson method approaches this problem by using the linear Taylor series expansion for $f(P)$:

$$f(P) \approx f(P^{(t)}) + D(P^{(t)})(P - P^{(t)}) \tag{3.3}$$

Setting $f(P) = 0$ and solving for $P = P^{(t+1)}$, yields

$$P^{(t+1)} = P^{(t)} - D^{-1} f(P^{(t)}) \tag{3.4}$$

This describes a tatonnement process where the direction vector is given by $-D^{-1}f$ and the step size is equal to 1. The Powell algorithm used in this model derives the matrix of derivatives by numerical approximation, thus making an analytic specification of the derivatives of $f(P)$ – in this case the excess demand functions – unnecessary. The procedure is more fully documented in the methodological appendices of Adelman and Robinson (1978) and Dervis et al. (1982).

The greater efficiency of the algorithm in computing a larger number of prices as compared to fixed-point algorithms comes at the cost of not having a guarantee of convergence. Nevertheless, past experience with it has shown it to be rather robust, and this observation has been borne out in work with the Philippine model as well. It was found that, in cases where the model failed to converge to a solution, the problem lay in the specification of the model (i.e., in its "economics"), and not in the algorithm itself.

4. CONCLUDING REMARKS

Any economic model has its inherent limitations which must be recognized whenever one interprets results of analyses undertaken with it. Often, these limitations are addressed by continuous modifications and improvements on the model. The current work on the Philippine CGE model is precisely of this nature. Aside from redefining the scope and aggregation level of the model to make it more suitable to agricultural policy analysis, work is being undertaken to alleviate some of its limitations, including (1) allowing for interinput substitutions in response to price changes; (2) allowing for nonzero cross-price elasticities in consumer demands; and (3) permitting endogenous determination of factor supplies, particularly of labor. With direct estimation of production and consumption parameters being undertaken as part of the overall research project, it is hoped that this work will move the CGE model beyond the stage of simply demonstrating its potential usefulness for policy analyses, and actually deriving valid policy implications from it.

REFERENCES

Adelman, Irma, and Sherman Robinson. *Income Distribution Policy in Developing Countries.* Oxford: Oxford University Press, 1978.

Clarete, Ramon. "The Cost and Consequences of Trade Distortions in a Small Open Economy: A General Equilibrium Model of the Philippines." Ph.D. dissertation, University of Hawaii, 1984.

David, Cristina C. "Government Policies and Philippine Agriculture." Philippine Institute for Development Studies Working Paper, 1983.

Dervis, Kemal; Jaime de Melo; and Sherman Robinson. *General Equilibrium Models for Development Policy.* Cambridge: Cambridge University Press, 1982.

Goulder, Lawrence H. "A General Equilibrium Analysis of U.S. Energy Policies." Ph.D. dissertation, Stanford University, 1982.

Habito, Cielito F. "Equity and Efficiency Tradeoffs in Philippine Tax Policy Analysis: A General Equilibrium Approach." Ph.D. dissertation, Harvard University, 1984.

Merrill, O. H. "Applications and Extensions of an Algorithm that Computes Fixed Points of Certain Upper Semi-Continuous Mappings." Ph.D. dissertation, University of Michigan, 1971.

Powell, M. J. D. "A Hybrid Method for Nonlinear Equations." In *Numerical Methods for Non-linear Algebraic Equations,* edited by Rabinowitz. New York: Gordon and Breach, 1970.

Scarf, Herbert. "The Computation of Equilibrium Prices: An Exposition." Cowles Foundation Discussion Paper No. 473, Yale University, 1977.

Shoven, J., and J. Whalley. "Applied General Equilibrium Models of Taxation and International Trade." *Journal of Economic Literature* 22 (1984): 1007-51.