Agricultural Economics, 1 (1986) 67-85
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

Effects of Increasing Agricultural Productivity in a Multisectoral Model for the Philippines

Romeo M. Bautista
International Food Policy Research Institute, Suite 800, 1776 Massachusetts Avenue, N.W., Washington, DC 20036 (U.S.A.)

(Accepted 3 October 1986)

Abstract

Bautista, R.M., 1986. Effects of increasing agricultural productivity in a multisectoral model for the Philippines. Agric Econ., 1: 67-85.

This paper investigates empirically the economy-wide effects of agricultural productivity increases in the Philippines, reporting the results of a quantitative analysis based on a general equilibrium framework. A multisectoral, price endogenous model of the Philippine economy is employed, emphasizing not only agriculture but also other production sectors with which it closely interacts, as well as the distinction between rural and urban households in their income generation and consumption patterns. Among other findings, the differential effects on the real income of rural households vis-a-vis urban households arising from increased productivity in the various components of the agricultural production sector are striking. The resulting improvements in the trade balance and national income, among other macroeconomic variables, are also relatively significant. Moreover, there are significant differences in the economy-wide effects among the four sectors of food and agriculture distinguished in the study. Particularly interesting is the highly favorable impact of rising productivity in the food processing sector on agricultural crop production and rural income, a linkage effect that has not received much attention in the development literature.

Introduction

There has recently been increasing attention given by development economists to the stimulation of the domestic market in developing countries (LDCs) as a means of coping with what is being perceived as an unfavorable external economic environment. Because of the substantial, if not dominant, impor-

0169-5150/86/$03.50

tance of the agricultural sector in most LDC economies, raising agricultural productivity and rural incomes seems to represent a logically attractive option for policymakers to promote economic growth. It would generate increased demand not only for food and other agricultural products but also for industrial goods and services through intermediate and final demand linkages (Mellor, 1976; Adelman, 1984). Moreover, the lower import requirement of agricultural production implies a foreign exchange saving relative to the encouragement of the more import dependent nonagricultural sectors. This is of significant interest for developing countries like the Philippines which are currently facing severe balance-of-payments adjustment problems. Finally, in particular reference also to the Philippines where the rural–urban income differential is quite large (see below), raising rural incomes may well prove to be the most efficient means of improving income distribution.

It is of course not inevitable that rural incomes will rise with an improvement in agricultural productivity, in view of possible deterioration in the agricultural terms of trade arising from the price and income inelasticity of agricultural products. In analyzing the effects of increasing productivity, one needs to consider the linkage of the agricultural (rural) sector with the rest of the economy in terms not only of the rural demand for nonagricultural goods, but also of the rest-of-the-economy's demand for agricultural products. Other aspects of the LDC's economic structure are also relevant considerations, including the prevailing domestic policies. In short, partial equilibrium analysis is likely to prove inadequate.

This paper investigates empirically the static effects of agricultural productivity increases in the Philippines, reporting the results of a quantitative analysis based on a general equilibrium framework. A multisectoral, price-endogenous model of the Philippine economy is employed, emphasizing not only agriculture but also the other production sectors with which it closely interacts, as well as the distinction between rural and urban households in their income generation and consumption patterns. While the parameter values and initialization of the model are based on Philippine conditions, the results of the analysis could be of policy interest to other LDCs with similar structural characteristics.

A prerequisite to serious empirical analysis using a multisectoral model is that the underlying data set be consistent in an accounting sense. The second section of the paper presents a social accounting matrix for the Philippines in 1978, which constitutes the base period for the study. The year 1978 can be regarded, in a relative sense, to be a normal year on at least the following grounds: it is between the adjustment period to the oil price shock of 1973–1974 and the onset of the 1979–1980 oil price shock. This is a major consideration in the Philippine context in view of the economy's vulnerability to drastic oil price increases (Alejo, 1983). The choice of base year 1978 was also favored by the additional consideration of data availability.

The structure of the analytical model, which is built around the social accounting framework, is described in the third section . It includes the behavioral relationships concerning sectoral production, consumption, trade, employment and prices, and their interactions. The effects of exogenous increases in agricultural productivity are quantified in the section after that, through model simulations with no change in base period policies. Concluding comments are given in the last section.

A social accounting matrix for the Philippines, 1978

Tables 1 and 2 portray the input–output structure of the Philippine economy in 1978, distinguishing ten production sectors with intersectoral linkages in output sales and intermediate input purchases, sectoral payments to primary factors and government, final consumption demands coming from households and government, and other final demands for capital formation (including stock changes) and export. Imports appear as negative entries in a final demand column (Table 2) and are sectorally combined with competing domestic products in Table 1.

The contributions of sectors 1–3 (food crops, export crops, and livestock and fishing) to the total value of output are seen, from the last column of Table 2, to be roughly equal; their joint shares in total output and value added are 16.3 and 24.8%, respectively. While value of output produced in food manufactures (sector 4) exceeds total agricultural production, the combined value added in sectors 1–3 is 2.8 times that in the former sector (Table 1). "Light manufactures" (sector 8), mainly producing consumer goods, contributes less than "other manufactures" (sector 9) in both output value and value added, but generates more income for laborers. "Services" (sector 10), which *also* includes utilities, transportation and commerce, accounts for about 38% of the entire economy's output value, 45% of total value added, and 52% of total labor income.

Both forestry (sector 6) and mining (sector 7) are significantly trade-oriented, earning about one and three billion pesos of export revenues, respectively, in 1978. Since 1976 the volume of log exports has been quantitatively restricted due to environmental concerns and as an encouragement to the domestic wood processing industry. The country's mining imports, principally crude oil, are seen to be more than twice the earnings from copper concentrates and other mining exports. Fertilizer (sector 5) is also given special attention, despite its small size, in view of its important link to agricultural crop production (accounting for more than one-half of extra-sectoral intermediate input purchases in both the food and export crop sectors).

The individual accounts of rural households, urban households, companies (corporations and "unincorporated business"), and government are shown in Tables 3–5, while the rest-of-the-world and saving-investment accounts are given in Tables 6 and 7. The principal sources of data (and values of share

TABLE 1

Intersectoral transactions and income generation (1978, billion pesos)

Sector	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8	Sector 9	Sector 10	Intermediate demand
1. Food crops	0.61	0.33	0.15	12.82	–	–	–	0.78	0.05	0.13	14.77
2. Export crops	0.39	1.28	0.13	6.42	–	–	–	1.30	0.05	0.21	9.78
3. Livestock and fishing	–	–	0.44	4.89	–	–	–	–	–	0.41	5.74
4. Food manufactures	–	–	1.76	8.46	–	–	–	0.36	0.95	1.65	13.18
5. Fertilizer	0.81	0.62	0.07	–	–	–	–	–	–	–	1.50
6. Forestry	–	–	–	0.02	–	0.49	0.05	2.65	0.02	0.12	3.35
7. Mining	–	–	0.02	0.06	0.38	–	0.10	–	7.49	0.57	8.62
8. Light manufactures	0.02	0.02	0.33	0.24	–	0.03	0.06	11.86	0.47	4.46	17.49
9. Other manufactures	0.11	0.12	0.24	1.24	0.42	0.43	0.93	2.71	11.58	9.70	27.48
10. Services	0.22	0.16	0.68	5.60	0.17	0.34	0.48	3.48	4.65	22.19	37.97
Subtotal	2.15	2.43	3.82	39.75	0.97	1.29	1.62	23.14	25.26	39.44	139.88
Labor income	6.80	5.52	5.33	3.81	0.11	1.17	0.61	3.73	3.33	32.80	63.22
Nonlabor value added	7.16	8.42	7.92	9.48	0.22	3.17	2.13	6.04	8.78	37.28	90.60
Indirect taxes											
less subsidies	0.27	0.39	0.55	1.81	0.05	0.39	0.57	2.33	3.24	7.05	16.66
Subtotal	14.33	14.33	13.80	15.10	0.38	4.73	3.31	12.10	15.35	77.14	170.48
Total	16.38	16.76	17.62	54.85	1.35	6.02	4.93	35.24	40.62	116.59	310.36

TABLE 2

Sectoral demand (1978, billion pesos)

Sector	Intermediate demand	Household consumption	Government consumption	Capital formation	Exports	Imports	Total final demand	Total value of output
1	14.77	2.95	0.03	0.43	–	–1.80	1.61	16.38
2	9.78	4.45	0.04	0.41	2.08	–	1.98	16.76
3	5.74	11.63	0.10	0.12	0.04	–0.02	11.87	17.62
4	13.18	34.54	0.26	1.72	7.00	–1.85	41.67	54.85
5	1.50	–	–	0.08	–	–0.23	–0.15	1.35
6	3.35	0.98	–	0.79	0.96	–0.06	2.67	6.02
7	8.62	–	–	1.07	3.09	–7.85	–3.69	4.93
8	17.49	13.51	1.94	1.83	3.99	–3.52	17.75	35.24
9	27.48	11.06	2.60	19.83	2.54	–22.89	13.14	40.62
10	37.97	32.88	12.35	24.89	11.61	–3.11	78.62	116.59
Total	139.88	112.00	17.32	51.17	31.31	–41.33	170.48	310.36

TABLE 3

Rural and urban household accounts (1978, billion pesos)

	Rural	Urban		Rural	Urban
Total receipts	61.14	72.67	Total expenditures	61.14	72.67
Value added	39.28	49.04	Consumption expenditures	57.93	54.06
Sector 1	8.84	0.75	Sector 1	2.29	0.66
Sector 2	7.18	0.61	Sector 2	2.65	1.80
Sector 3	6.93	0.59	Sector 3	6.58	5.05
Sector 4	1.68	3.63	Sector 4	19.24	15.30
Sector 5	–	0.15	Sector 5	–	–
Sector 6	1.52	0.13	Sector 6	0.52	0.46
Sector 7	0.31	0.54	Sector 7	–	–
Sector 8	1.64	3.56	Sector 8	6.20	7.31
Sector 9	1.47	3.17	Sector 9	4.58	6.48
Sector 10	9.71	35.91	Sector 10	15.88	17.00
Transfers from:			Direct taxes	1.88	3.42
Companies	19.95	21.62	Savings	1.33	16.21
Government	1.14	1.70			
Rest-of-the-world	0.77	1.32			

parameters) are the following: the Input–Output Tables for 1978 and 1979 compiled by the National Census and Statistics Office, the unpublished 1978 Social Accounting Matrix prepared by the Statistical Coordination Office, the 1974 and 1972 SAM tables presented, respectively, in Samson and Buenaventura (1980) and Bull (1977), and the *1982 Philippine Statistical Yearbook* (published by the National Economic and Development Authority) which contains the national income accounts for 1978, among other data. Because the available data are not always consistent and complete, adjustments have been made informally to ensure a consistent and plausible set of entries in the various accounts.

TABLE 4

Companies account (1978, billion pesos)

Total receipts	61.03
Value added	61.03
Total expenditures	61.03
Distributed income to:	
Rural households	19.95
Urban households	21.62
Tax payments	2.12
Savings	17.34

TABLE 5

Government account (1978, billion pesos)

Total receipts	28.54
Value added	4.46
Income tax receipts from:	
Rural households	1.88
Urban households	3.42
Companies	2.12
Other taxes	16.66
Total expenditures	28.54
Consumption expenditures	17.33
Transfers to:	
Rural households	1.14
Urban households	1.70
Savings	8.37

Tables 1–7 together represent a social accounting matrix of the Philippine economy for 1978, integrating input–output, national income, flow-of-funds and foreign accounts into a comprehensive and consistent data set. Such an accounting system provides the framework around which is built the analytical

TABLE 6

Rest-of-the-world account (1978, billion pesos)

Total receipts	41.32
Exports	31.31
Income transfers to:	
Rural households	0.77
Urban households	1.32
Savings	7.92
Total expenditures	41.32
Imports	41.32

TABLE 7

Investment and savings (1978, billion pesos)

Total investment	51.17
Total savings	51.17
Rural households	1.33
Urban households	16.21
Companies	17.34
Government	8.37
Rest-of-the-world	7.92

model used in the present study to estimate the economy-wide effects of agricultural productivity increases in the Philippines.

The model

Markets for goods, labor, and foreign exchange are assumed to respond to changing demand and supply conditions, which in turn are affected by government policies, the external economic environment, and other exogenous influences. Potential demand and supply imbalances are reconciled by adjustments of prices and, in some cases, of quantities – which variables are determined endogenously by the multisectoral model on a simultaneous, economy-wide basis. The model is Walrasian in that it determines only relative prices and other variables in the real sphere of the economy. A price normalization rule fixes the absolute price level such that sectoral prices, as well as the wage and foreign exchange rates, are defined relative to an aggregate price level.

Following the now commonly-used distinction of demand for products by place of production pioneered by Armington (1969), the model generally assumes that sectoral imports and domestic products are imperfect substitutes. A composite consumption good is defined to represent an aggregation of domestic and imported products in a given sector; there is a constant elasticity of substitution between them, a smaller elasticity value indicating greater difficulty in substituting one for the other in response to changes in their relative prices. Such product differentiation permits two-way trade and provides some autonomy to the domestic price system not found in models that assume perfect substitutability between domestic production and imports (De Melo and Robinson, 1981).

The equations of the model are given in Table 8, the variables and parameters being defined in Table 9. They are grouped into six blocks, which we describe in turn.

Production, employment, and wage rates

Production technology is represented by fixed input–output coefficients for intermediate inputs and Cobb–Douglas functions for capital and labor, except for the two agricultural crop sectors. Food and export crops are jointly produced, and both variable and fixed inputs can be reallocated between them. Equations (1)–(4) constitute a system of output supply and variable input demand functions for the food and export crop sectors. Based on the profit function approach, the common arguments of these functions are the producer prices of food and export crops, prices of the variable inputs represented by fertilizer and agricultural labor, and quantities of the fixed inputs (cf. Bautista, 1984).

Equations (5)–(12) and (13)–(20) express, respectively, the Cobb–Douglas

TABLE 8

Model equations

I. Production, employment, and wage rates

$$Q_{x1} = Q_{x1}(P_{d1}, P_{d2}, P_{c5}, W_a; Z) \qquad (1)$$
$$Q_{x2} = Q_{x2}\ (P_{d1}, P_{d2}, P_{c5}, W_a; Z) \qquad (2)$$
$$-Q_{a5} = Q_{a5}\ (P_{d1}, P_{d2}, P_{c5}, W_a; Z) \qquad (3)$$
$$-L_a = L_a\ (P_{d1}, P_{d2}, P_{c5}, W_a; Z) \qquad (4)$$
$$Q_{xi} = A_i K_i^{1-\alpha_i} L_i^{\alpha_i} \quad i=3,\ldots,10 \qquad (5)\text{-}(12)$$
$$L_i = B_i L_{ni}^{1-\beta_i}\ L_{si}^{\beta_i} \quad i=3,\ldots,10 \qquad (13)\text{-}(20)$$
$$h_{ni}\ W_a = \alpha_i(1-\beta_i)\ L_{ni}^{-1}\ P_{vi}\ Q_{xi} \quad i=3,\ldots,10 \qquad (21)\text{-}(28)$$
$$h_{si}\ W_s = \alpha_i\ \beta_i\ L_{si}^{-1}\ P_{vi}\ Q_{xi} \quad i=3,\ldots,10 \qquad (29)\text{-}(36)$$
$$L_a + \sum_{i=3}^{10} L_{ni} = L_n \qquad (37)$$
$$\sum_{i=3}^{10} L_{si} = L_s \qquad (38)$$

II. Sectoral demand and final consumption

$$Q_{xi} = Q_{di} + Q_{ei} \quad i \neq 1, 5 \qquad (39)\text{-}(46)$$
$$Q_{x1} = Q_{d1} \qquad Q_{x5} = Q_{d5} \qquad (49)\text{-}(48)$$
$$Q_{ci} = \sum_{j=1}^{10} a_{ij}\ Q_{xj} + C_i + I_i \quad i \neq 5 \qquad (49)\text{-}(57)$$
$$Q_{c5} = Q_{a5} + I_5 \qquad (58)$$
$$C_i = C_{ri} + C_{ui} + C_{gi} \quad i \neq 5, 7 \qquad (59)\text{-}(66)$$
$$P_{ci}\ C_{ri} = P_{ci}\ \bar{C}_{ri} + \mu_{ri}\ (\gamma_r\ Y_r - \textstyle\sum_j P_{cj}\ \bar{C}_{rj}) \quad i \neq 5, 7 \qquad (67)\text{-}(74)$$
$$P_{ci}\ C_{ui} = P_{ci}\ \bar{C}_{ui} + \mu_{ui}\ (\gamma_u\ Y_u - \textstyle\sum_j P_{cj}\ \bar{C}_{uj}) \quad i \neq 5, 7 \qquad (75)\text{-}(82)$$
$$P_{ci}\ C_{gi} = \theta_{gi}\ \gamma_g\ Y_g \quad i \neq 5, 6, 7 \qquad (83)\text{-}(89)$$
$$Q_{di} = d_i\ (P_{ci}/P_{di})^{\sigma i} Q_{ci} \quad i \neq 2, 5 \qquad (90)\text{-}97)$$
$$Q_{d2} = Q_{c2} \qquad Q_{d5} = Q_{c5} - Q_{m5} \qquad (98)\text{-}(99)$$

III. Prices

$$P_{mi} = P_{mi}^*\ (1+t_{mi}) R \quad i \neq 2 \qquad (100)\text{-}(108)$$
$$P_{di} = P_{ei}^*\ (1-t_{ei}) R \quad i \neq 1, 5 \qquad (109)\text{-}(116)$$
$$P_{ci} = (P_{di}\ Q_{di} + P_{mi}\ Q_{mi})/Q_{ci} \quad i \neq 2 \qquad (117)\text{-}(125)$$
$$P_{c2} = P_{d2} \qquad (126)$$
$$P_{vi} = (1-t_{xi})\ P_{di} - \textstyle\sum_j \mathrm{a}_{ji}\ P_{cj} \quad i=3,\ldots,10 \qquad (127)\text{-}(134)$$
$$P = \textstyle\sum_i \phi_{xi}\ P_{di} \qquad (135)$$

IV. Income, savings, and investment

$$V_a = \sum_{i=1,2} (1-t_{xi}) P_{di} Q_{xi} - \sum_{j \neq 5} (a_{j1} Q_{d1} + a_{j2} Q_{d2})\ P_{cj} - P_{c5} Q_{a5} \qquad (136)$$
$$V_{NL} = (V_a - W_a L_a) + \sum_{i=3}^{10} (1-\alpha_i) P_{vi} Q_{xi} \qquad (137)$$
$$Y_r = (1-t_r)\ \{\alpha_{Lra} W_a L_a + \alpha_{NLra}\ (V_a - W_a L_a) + \sum_{i=3}^{10} [\alpha_{Lri}\alpha_i + \alpha_{NLri}(1-\alpha_i)] P_{vi} Q_{xi} + c_r \alpha_{NLc} V_{NL} + G_{tr} + Y_{fr}\} \qquad (138)$$
$$Y_u = (1-t_u)\ \{\alpha_{Lua} W_a L_a + \alpha_{NLua}\ (V_a - W_a L_a) + \sum_{i=3}^{10} [\alpha_{Lui}\alpha_i + \alpha_{NLui}\ (1-\alpha_i)]\ P_{vi} Q_{xi} + c_u \alpha_{NLc} V_{NL} + G_{tu} + U_{fu}\} \qquad (139)$$
$$Y_c = (1-t_c)\ (1-c_r-c_u) \alpha_{NLc} V_{NL} \qquad (140)$$

TABLE 8 *(continued)*

(IV. Income, savings, and investment)	
$Y_g = \alpha_{NLg} V_{NL} + t_r Y_r/(1-t_r) + t_u Y_u/(1-t_u)$	
$+ t_c Y_c/(1-t_c) + R\left(\sum_i t_{mi} P^*_{mi} Q_{mi} + \sum_i t_{ei} P^*_{ei} Q_{ei}\right)$	
$+ \sum_i t_{xi} P_{di} Q_{xi} - (G_{tr} + G_{tu})$	(141)
$I = \sum_k (1-\gamma_k) Y_k + S^*_f R \quad k = r, u, c, g$	(142)
$P_{ci} I_i = \phi_{Ii} I$	(143)-(152)
V. Foreign trade	
$Q_{ei} = \bar{Q}_{ei} \ (P^*_{ei})^{-\xi_i} \quad i \neq 1, 5, 6$	(153)-(159)
$Q_{mi} = m_i \ (P_{mi}/P_{ci})^{-\sigma_i} Q_{ci} \quad i \neq 2, 5$	(160)-(167)
$Q_{m5} = s_{m5} \ Q_{c5}$	(168)
$\sum_i P^*_{mi} Q_{mi} - \sum_i P^*_{ei} Q_{ei} = S^*_f + (Y_{fr} + Y_{fu})/R$	(169)

TABLE 9

Definition of Variables and Parameters

Endogenous variables			Number of variables
Q_{xi}	=	Sectoral production	10
Q_{ci}	=	Sectoral consumption	10
Q_{a5}	=	Fertilizer demand in agricultural crop production	1
Q_{di}	=	Consumption of sectoral domestic products	10
Q_{mi}	=	Sectoral imports, $i \neq 2$	9
Q_{ei}	=	Sectoral exports, $i \neq 1, 5, 6$	7
L_a	=	Employment in agricultural crop production	1
L_i	=	Sectoral employment, $i = 3, \ldots, 10$	8
L_{ni}	=	Sectoral employment of unskilled labor, $i = 3, \ldots, 10$	8
L_{si}	=	Sectoral employment of skilled labor, $i = 3, \ldots, 10$	8
W_a	=	Agricultural wage rate	1
W_s	=	Average wage rate for skilled labor	1
C_i	=	Final consumption demand, $i \neq 5, 7$	8
C_{ri}	=	Consumption of rural households, $i \neq 5, 7$	8
C_{ui}	=	Consumption of urban households, $i \neq 5, 7$	8
C_{gi}	=	Consumption of government, $i \neq 5, 6, 7$	7
Y_r	=	Disposable (after tax) income of rural households	1
Y_u	=	Disposable (after tax) income of urban households	1
Y_c	=	Disposable income of companies (after transfers to households)	1
Y_g	=	Disposable income of government (after transfers to households)	1
P_{ci}	=	Price of composite consumption goods	10
P_{di}	=	Price of domestic products	10
P_{mi}	=	Price of imported products, $i \neq 1, 2, 5$	7
t_{m1}	=	Tax rate on food crop imports	1
t_{m5}	=	Tax rate on fertilizer imports	1
P^*_{ei}	=	Foreign price of sectoral exports, $i \neq 1, 5$	8
P_{vi}	=	Sectoral value added per unit output, $i = 3, \ldots, 10$	8
V_a	=	Value added in agricultural crop production	1
V_{NL}	=	Total nonlabor value added	1
I	=	Total investment	1
I_i	=	Sectoral investment demand	10
R	=	Exchange rate	1
		Total	168

TABLE 9 *(continued)*

Exogenous variables and parameters		
P	=	General price level
P_{m1}	=	Government-determined price of imported food crops
P_{m5}	=	Government-determined price of imported fertilizer
P^*_{mi}	=	Foreign price of imports, $i \neq 2$
Q_{e6}	=	Government-determined quantity of forestry exports
$\bar{Q}_{ei}$	=	Scale variable in sectoral export demand function
G_{tr}, G_{tu}	=	Government income transfer to rural (urban) households
K_i	=	Sectoral capital stock, $i = 3, \ldots, 10$
L_n, L_s	=	Total supply of unskilled (skilled) labor
S_f^*	=	Foreign capital inflow
s_{m5}	=	Share of imports in total fertilizer supply
Y_{fr}, Y_{fu}	=	Income from abroad received by rural (urban) households
Z	=	Vector of quantities of fixed inputs and other supply shifters in crop production
a_{ij}	=	Sectoral input-output coefficients
A_i	=	Productivity parameter in sectoral Cobb-Douglas production function, $i = 3, \ldots, 10$
B_i	=	Scale parameter in sectoral Cobb-Douglas labor aggregation function, $i = 3, \ldots, 10$
α_i	=	Output elasticity with respect to composite labor, $i = 3, \ldots, 10$
β_i	=	Composite labor elasticity with respect to skilled labor, $i = 3, \ldots, 10$
$\alpha_{Lra}, \alpha_{Lua}$	=	Labor income share of rural (urban) households in agricultural crop production
$\alpha_{NLra}, \alpha_{NLua}$	=	Nonlabor income share of rural (urban) households in agricultural crop production
$\alpha_{Lri}, \alpha_{Lui}$	=	Sectoral labor income share of rural (urban) households, $i = 3, \ldots, 10$
$\alpha_{NLri}, \alpha_{NLui}$	=	Sectoral nonlabor income share of rural (urban) households, $i = 3, \ldots, 10$
$\alpha_{NLc}, \alpha_{NLg}$	=	Share of companies (government) in total nonlabor value added
ϕ_{Ii}	=	Share in total investment by sector of origin
ϕ_{xi}	=	Sectoral share in total value of domestic production
ϕ_{ki}	=	Sectoral share in total consumption expenditure of consuming class k
γ_k	=	Ratio of total consumption expenditures to disposable income of consuming class k
ξ_i	=	Sectoral export demand elasticity, $i \neq 1, 5, 6$
σ_i	=	Sectoral elasticity of substitution between domestic and imported products, $i \neq 2, 5$
c_r, c_u	=	Share of rural (urban) households in income transfer from companies
t_r, t_u, t_c	=	Tax rate on rural (urban, company) income
t_{mi}, t_{ei}	=	Sectoral import (export) tax rates, $i \neq 1, 5$
t_{xi}	=	Sectoral indirect tax rates
h_{ni}, h_{si}, d_i, m_i	=	Constants of proportionality

Notes: Production sector $i = 1$ (food crops), 2 (export crops), 3 (livestock and fishery), 4 (food manufactures), 5 (fertilizer), 6 (forestry), 7 (mining), 8 (light manufactures), 9 (other manufactures), 10 (services). Consuming class k = r (rural households), u (urban households), c (corporations and other enterprises), g (government).

specification of production and aggregation of unskilled and skilled labor in sectors 3 through 10. Capital is assumed sectorally fixed; once installed it is not freely mobile across sectors. Labor demand is generated from profit-maximizing behavior of producers. In eqns. (21)–(28) and (29)–(36) the marginal value products of unskilled and skilled labor are equated to their sectoral wage rates. Unskilled labor wage in each sector is assumed to remain in constant proportion to the agricultural wage rate, and intersectoral wage differentials for skilled labor (as observed in the base period) are also fixed.

Total demand for agricultural and unskilled labor, assumed substitutable and mobile across sectors (cf. Lal, 1986), is equated to the exogenously given supply in eqn. (37). Finally, in eqn. (38), the total demand for skilled labor is equated to the fixed supply.

Sectoral demand and final consumption

The sum of domestic and export demand is equal to sectoral production (eqns. 39–46); reflecting the trade structure in 1978, eqns. (47) and (48) rule out exports in sectors 1 and 5. Demand for each sector's composite consumption goods, except fertilizer (sector 5), is defined in eqns. (49)–(57) as the sum of intermediate demand based on constant input coefficients, investment demand, and final consumption demand. In eqn. (58) total fertilizer demand consists of the intermediate demand from crop production and investment demand (change in stock).

Final consumption demand is defined in eqns. (59)–(66) as the sum of demands from rural households, urban households, and government. Equations (67)–(74) and (75)–(82) specify sectoral consumption levels based on the linear expenditure system (LES), a widely used complete set of demand equations, for rural and urban households, respectively. Sectoral consumption demand by government is assumed in eqns. (83)–(89) to be determined simply by constant expenditure shares.

Assuming that demanders of imported and domestic products seek to minimize the cost of obtaining a given amount of composite goods, the first-order conditions yield a relationship between the ratio of domestic to composite goods and their relative prices (eqns. 90–97). Export crops (sector 2) are not imported, while domestic and imported fertilizer (sector 5) products are assumed perfectly substitutable (eqns. 98–99).

Prices

Assuming an infinitely elastic world supply of imported products, the domestic price of sectoral imports is determined by the exogenous foreign price, exchange rate and tariff rate, as shown in eqns. (100)–(108). Since the government effectively controls the prices of imported food crops and fertilizer to domestic users, the implicit import taxes are the endogenous variables, rather than the domestic prices of imports for sectors 1 and 5. The country is not assumed "small" in the export side; eqns. (109)-(116) represent the relationship between the prices of export products in the domestic and foreign markets.

Sectoral prices of the composite consumption goods are the weighted averages of the prices of imported and domestic products (eqns. 117–126). A net price or value added coefficient for each sector is defined in eqns. (127)-(134) as the unit value of output net of indirect taxes minus the cost of intermediate inputs. In eqn. (135) the price normalization rule fixes an aggregate price index of domestic products.

Income, savings, and investment

The definitions of value added generated in crop agriculture and by nonlabor factors are given in eqns. (136) and (137), respectively. Disposable incomes of rural households, urban households, companies, and government are represented, respectively, in eqns. (138), (139), (140), and (141). Government transfers and foreign remittances to rural and urban households are exogenous, while constant shares of total company earnings distributed to the two household classes are assumed.

Savings of rural and urban households, companies, and government are each a fixed proportion of disposable income. Investment is determined by total savings, including exogenous foreign savings (net capital inflow), as shown in eqn. (142). Investment expenditures by sector of origin are assumed to be constant proportions of total investment (eqns. 143–152).

Foreign trade

Foreign demand functions for sectoral exports, given in eqns. (153)-(159), are genelrally assumed downward sloping. The exception is in sector 6 (forestry) where, as pointed out above, the government directly controls the volume of log exports. Apart from the foreign currency export price (which is endogenously determined), an exogenous variable reflecting the state of world demand is included as an additional determinant of sectoral exports.

Analogous to the earlier specification of sectoral demand for domestic products, eqns. (160)-(167) express import demand as a function of total demand for the composite good and the relative price of sectoral imports. In the case of fertilizer (eqn. 168), for which domestic and imported products are not differentiated, the share of imports to total domestic use is determined exogenously.

The last equation (169) describes the balance of payments, equating the trade deficit to the sum of foreign savings and remittances.

The number of endogenous variables in the model is 168 (as indicated in Table 9), which is one less than the number of equations. Since the system is homogenous of degree zero in prices and wages, it can only determine relative prices. The price normalization equation (135) fixes the absolute price level, reducing the number of independent equations to 168. The balance of payments equation (169) may then be considered a derived relationship; it is not an independent restriction but one which can be used as a convenient check on the numerical solution of the model.

Effects of increasing agricultural productivity

To examine empirically the effects of agricultural productivity increases with no change in base period policies, an initial situation of static equilibrium is assumed for the Philippine economy, approximated by the observed conditions in 1978, so that the equations in Table 8 are satisfied. This nonlinear system of equations can be transformed, by logarithmic differentiation, into a set of equations linear in proportionate changes, expressing changes in the endogenous variables in terms of changes in the exogenous variables of the model. The coefficients in the transformed set of linear equations consist of the share parameters reflecting the initial situation of static equilibrium assumed for the Philippine economy in the benchmark year (1978), and the structural parameters in the untransformed nonlinear equation system. Values of the share parameters are computed directly from available data for 1978, most of which are contained in Tables 1 to 7 above. The other parameters are assigned values on the basis of formal statistical estimation done in previous studies on relevant aspects of the Philippine economy, or based on estimates used by other investigators in similar applications to other developing countries.[1]

In general the impact of given changes in any exogenous variables on the endogenous variables of the model can be calculated using simple matrix methods; that is, $y=A^{-1}x$, where y is a column vector of proportionate changes in the 168 endogenous variables, x is a column vector containing the asssumed changes in exogenous variables, and A^{-1} is the inverse of the 168×168 coefficient matrix. The analysis is one of comparative statics, assuming an adjustment period long enough for the direct and indirect effects of the exogenous shocks to work themselves out. The repercussions of agricultural productivity increases as quantified in the model simulations should be interpreted as deviations from a reference growth path of the economy with no change in base period values of the other exogenous variables and parameters of the model.

The stimulation experiments assume a 10% increase in total productivity separately in each of the three agricultural sectors (1 – food crops, 2 – export crops and 3 – livestock and fishing) and in food manufactures (sector 4) resulting from say, technological change and/or improved infrastructure. The

[1]An appendix to this paper entitled "Parameterization of the model", which describes the choice of parameter values and data sources used, is available from the author on request.

TABLE 10

Simulation results

	E-1	E-2	E-3	E-4	E-5
Sectoral prices					
Food crops, P_{d1}	−28.11	−4.37	−0.67	6.71	−26.44
Export crops, P_{d2}	−1.36	−9.61	−0.94	2.22	−9.69
Livestock, P_{d3}	0.15	−0.24	4.16	−0.92	3.15
Food manuf., P_{d4}	1.94	0.80	0.40	−5.06	−1.92
Sectoral output					
Food crops, Q_{x1}	1.80	0.64	−0.29	1.48	3.63
Export crops, Q_{x2}	3.09	8.19	−0.47	−0.39	10.42
Livestock, Q_{x3}	−0.16	−0.11	18.72	−1.33	17.13
Food manuf., Q_{x4}	1.40	0.65	−1.71	7.68	8.02
Cost-of-living (COL) index					
Rural, $P_r = \sum \phi_{cri} P_{ci}$	−0.60	−0.02	0.16	−1.52	−0.78
Urban, $P_u = \sum \phi_{cui} P_{ci}$	1.40	0.31	0.05	−1.33	0.48
Rural income					
Nominal, Y_r	−2.19	0.21	1.47	1.64	1.13
COL-adjusted, $Y_r \div P_r$	−2.79	0.23	1.31	3.16	1.91
Urban income					
Nominal, Y_u	2.10	2.05	−1.95	1.38	3.58
COL-adjusted, $Y_u \div P_u$	0.65	1.74	−2.00	2.71	3.10
Government income, Y_g	1.14	1.64	−0.95	1.83	3.66
Total investment, I	0.86	1.57	−1.18	1.35	2.60
Trade balance, B (in million U.S.$)	385	162	−45	86	588
National income, Y $\left(= V_a + \sum_{i+3}^{10} P_{vi} Q_{xi}\right)$	0.05	1.17	−0.35	1.30	2.17

Note: E-1, E-2, E-3, and E-4 refer to the simulation experiments involving a 10% increase in total productivity for sectors 1, 2, 3, and 4, respectively. E-5 assumes a simultaneous increase in total productivity for each of the four sectors.

All figures are percentage changes, except for trade balance (B), which is expressed in absolute changes where

$$\Delta B = E_o \sum_i \phi_{ei} (\hat{P}^*_{ei} + \hat{Q}_{ei}) - M_o \sum_i \phi_{mi} \hat{Q}_{mi}$$

E_o and M_o are base year (1978) exports and imports, respectively, in million U.S. dollars.

consequences of simultaneous productivity increases in the four sectors can also be inferred, since the linearity of the model (in proportionate changes) permits simple addition of the effects on the endogenous variables of any combination of exogenous disturbances.

Table 10 summarizes the results of the simulation experiments, focusing on the effects on output and product price for the four sectors, rural and urban incomes, and some macroeconomic variables of significant policy interest.

Increased productivity in the food crop sector (E-1)

As shown in the column labelled E-1, a very striking result is the sharp fall in the domestic price of the sectoral product – by 28%. This implies a huge excess supply initially created by the 10% rise in productivity, presumably related to the very low marginal budget share of food crops for both rural and urban households (0.033 and 0.008 respectively). (The marginal budget share is the product of the average budget share and the income elasticity. It should be noted that the two major food crops, rice (paddy) and corn, are consumed mostly in milled form (i.e., as products of sector 4) even among rural households. Also, sector 4 products are exportable; food crops are not). If the government does not intervene, the price decline will have a large negative effect on food crop production, significantly offsetting the expansionary impact of rising productivity. In final equilibrium, Q_{x1} is seen to increase by only 1.80%. Understandably, the income effect on rural households is adverse: cost-of-living adjusted rural income declines by 2.79%.

Food crop output goes mainly to the food processing sector as intermediate input. The reduced food crop price thus stimulates sector 4 production, which increases by 1.36%. Sectoral price of food manufactures is also seen to rise (by 1.94%).

Urban households gain, the increased urban income providing a net addition to government income and total investment due to the higher tax and saving rates out of urban income relative to rural income. There is a marked improvement in the trade balance, the $385 million increase representing about one-fourth of the 1978 Philippine trade deficit of $1495 million. National income also increases, albeit modestly (by 0.05%).

Increased productivity in the export crop sector (E-2)

The next column in Table 10 shows also a negative terms of trade effect arising from a 10% productivity increase for sector 2. Despite the 9.61% decline in the domestic price of export crops, however, sectoral production rises by 8.19%. These are relatively more favorable results compared to the previous experiment, the chief reason being that sector 2 products can be exported directly.

Rural income goes up slightly, while urban income increases more significantly, even after the cost-of-living adjustment. The effects on government income and total investment are also seen to be positive.

National income increases by 1.17%, while the trade balance improves by $162 million.

Increased productivity in the livestock and fishery sector (E-3)

In contrast with the results of the two previous experiments, the domestic price of setor 3 products does not decline but rises by 4.16%, owing to the high marginal budget share of livestock and fishery products (0.172 and 0.163 for rural and urban households, respectively). This represents a further encouragement to sectoral production, which goes up by 18.73%, apparently at the expense of sectoral output in crop agriculture and food processing. These are favorable results to rural households, whose income increases both before and after cost-of-living adjustment. On the other hand, urban households lose, their lower income contributing to the reduced government income and total investment.

The trade balance deteriorates by $45 million, while national income declines by 0.35%. It would appear that there exists in this case a tradeoff between rural welfare and some of the macroeconomic concerns of policymakers.

Increased productivity in the food processing sector (E-4)

The terms of trade effect is seen to be negative, but not as large as in the results of experiments E-1 and E-2. The domestic price of sector 4 products declines by only 5.06%, while sectoral production increases by 7.68%. The latter has a strong linkage effect on food crop output which rises by 1.48%, and on the domestic price of food crops which goes up by 6.71%.

The effects on both rural and urban incomes are favorable, especially after cost-of-living adjustment. The real purchasing power of rural households increases by 3.16%, that of urban households by 2.71%.

The aggregative variables also respond favorably to the productivity improvement in food manufactures. In particular, national income is observed to rise by 1.30%.

Increased productivity in all four sectors (E-5)

It is also of some policy interest to examine the effects of simultaneous productivity increases in the four sectors, considering that some agricultural infrastructure facilities are supportive of a wide range of production activities.

As shown in the last column in Table 10, simultaneous increases in total productivity in the agricultural and food processing sectors lead to a significant response in sectoral output, ranging from 3.63% for food crops to 17.13% for livestock and fishery. Despite the generally negative terms of trade effect (the exception is for sector 3 products, whose domestic price increases by 3.15%), rural income is observed to increase by 1.91% after the cost-of-living adjustment. Urban households gain even more (by 3.10%).

Also related to the adverse terms of trade effects of increasing agricultural productivity is the impact on the cost-of-living indices. It is favorable for rural households and unfavorable for urban households, the magnitude of the effect in either case being relatively moderate.

The overall effects on government income, total investment, and especially the trade balance are significantly positive. In the latter case the $588 million improvement is almost 40% of the actual deficit incurred in 1978. Finally, the observed 2.17% rise in national income induced by increasing productivity in sectors 1 to 4 represents also about two-fifths of the actual national income growth in the Philippines for 1978.

Conclusion

It seems clear from the above findings that the macroeconomic repercussions of increasing agricultural productivity in the Philippines are not negligible. Moreover, there are significant differences in the economy-wide effects among the four sectors of food and agriculture distinguished in the study. Particularly worth noting is the highly favorable impact of rising productivity in the food processing sector on agricultural crop production and rural income, a linkage effect that has not received much attention in the development literature. (In McCarthy and Taylor (1980) special attention is given to the link between the food processing setor and the staple crops; however, it does not examine the effects of productivity increases in the agricultural and food processing sector.)

The findings of the study also indicate that increasing agricultural productivity does not necessarily result in a reduction in rural income. But they provide empirical support to the view that agricultural productivity improvements are likely to benefit rural households less than urban households, owing to the deterioration in the agricultural terms of trade. This is an external diseconomy that presumably underlies some of the market intervention practices (e.g., agricultural price support) of LDC governments seeking to promote rural welfare. The challenge for policymakers is how to devise ways, at once economically efficient and politically feasible, that will ensure agricultural producers a greater share of the gains from increased productivity.

Acknowledgements

Earlier versions of this paper were presented in seminars at the University of the Philippines School of Economics and the Yale Economic Growth Center. Useful comments from the seminar participants, and from two anonymous referees of this journal are gratefully acknowledged. Assistance in data collection and computer work were provided by James Gilmartin and Stephen Haykin.

References

Adelman, I., 1984. Beyond export-led growth. World Dev., 12: 937-949.
Alejo, L.J., 1983. A Study of Energy-Economy Interaction in the Philippines. Monograph Series No. 1. Philippine Institute for Development Studies, Makati.
Armington, P., 1969. A theory of demand for products distinguished by place of production. IMF Staff Pap., 16: 159-178.
Bautista, R.M., 1984. Domestic price distortions and agricultural income in developing countries. International Food Policy Research Institute, Washingtron, DC (mimeograph); forthcoming in the J. Dev. Econ.
Bull, R., 1977. The use of a social accounting matrix for development planning in the Philippines. J. Philippine Dev., 4: 223-256.
De Melo, J. and Robinson, S., 1981. Trade policy and resource allocation in the presence of product differentiation. Rev. Econ. Stat., 63: 169-177.
Lal, D., 1986. Stoper-Samuelson-Rybczynski in the Pacific: Real wages and exchange rates in the Philippines, 1956-78. J. Dev. Econ., 21: 181-204.
McCarthy, F.D. and Taylor, L., 1980. Macro food policy planning: A general equilibrium model for Pakistan. Rev. Econ. Stat., 62: 107-121.
Mellor, J.W., 1976. The New Economics of Growth. Cornell University Press, Ithaca, NY.
Samson, P.Q. and Buenaventura, A.R., 1980. Social accounting matrices: The Philippine experience. Second National Convention on Statistics: Papers and Proceedings. National Census and Statistics Office, Manila, pp. 87-114.