Agricultural Economics, 3 (1989) 345-364
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

Agricultural Technology and Farm–Nonfarm Growth Linkages

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Abstract

Haggblade, S. and Hazell, P., 1989. Agricultural technology and farm–nonfarm growth linkages. *Agric. Econ.*, 3: 345–364.

Agricultural growth stimulates rural nonfarm activity by boosting demand for production inputs and consumer goods. But different kinds of agricultural technology promote different patterns of nonfarm linkages. To explore how key features of agricultural technology affect growth in the rural nonfarm economy, this paper reviews an array of cross-section and time-series evidence bearing on the dynamics of the rural nonfarm economy. Then, using consumption and production parameters associated with different agricultural technologies, it introduces a simple model which isolates the effects of different technologies on nonfarm growth linkages.

1. Introduction

Improved agricultural technology holds the key to increasing food production in many developing countries. Yet technological change requires costly investments in research and extension. Since government must typically provide them, such investments must be justified by their economic and social benefits.

Several studies have shown that technology-driven agricultural growth can contribute significantly to growth in national income (Byerlee, 1973; Cavallo and Mundlak, 1982; Rangarajan, 1982; Adelman, 1984). A large, if more contentious literature, discusses the poverty-reducing impact of technological change (see Lipton, 1985 and Pinstrup-Andersen and Hazell, 1985 for recent reviews).

Nonfarm linkages generated by technical change in agriculture can accentuate both the growth and the poverty-reducing impact of agricultural growth. A growing agriculture demands nonfarm production inputs and supplies raw materials to transport, processing and marketing firms. Likewise, increases in farm income lead to greater demand for consumer goods and services. In ad-

0169-5150/89/$03.50

dition to stimulating national economic growth, these production and consumption linkages affect poverty and spatial growth patterns, particularly when agricultural growth is focused on small- and medium-sized farms (Johnston and Kilby, 1975; Mellor, 1976; and Mellor and Johnston, 1984). Because much of the resultant growth in nonfarm activity is located in rural areas and small towns, it can contribute to the containment of excessive rural to urban migration. Moreover,the kinds of nonfarm goods and services demanded by small- and medium-sized farms are often those produced by small, labor-intensive enterprises whose growth can contribute to increased employment and income-earning opportunities for the poor.

But different agricultural technologies generate different patterns of nonfarm linkages. The input intensity, consumption profile of targeted farms and processing characteristics of the farm output all affect the size and composition of nonfarm spinoffs. So too do the multiplier effects vary across countries as a result of differing institutions, population densities, spatial settlement patterns and policy environments. The goal in this paper is to explore how key features of agricultural technology affect nonfarm growth linkages. This is done in two ways: (a) by reviewing an array of cross-section and time-series evidence bearing on the dynamics of rural nonfarm economies, and (b) through use of a simple model which isolates the effects on nonfarm growth linkages of consumption and production parameters associated with different agricultural technologies.

2. Importance of the rural nonfarm economy

Nonfarm activity occupies an important place in rural economies throughout the developing world, particularly in Asia and Latin America. While nonfarm enterprises account for only 14% of full-time employment in rural Africa, their employment share jumps to 26% in Asia and to 28% in Latin America (Table 1). When rural towns are included, nonfarm employment shares increase appreciably, rising to 19, 36 and 47%, respectively. The employment densities in Table 1 Panel B confirm the weaker pattern of nonfarm employment in rural Africa.

Income shares – which unlike employment data include earnings from part-time and seasonal activity – underscore the importance of rural nonfarm activity. They show nonfarm earnings contributing 25–30% of income in rural Africa and 30–40% in Asia and Latin America, sometimes more when rural towns are included (Chuta and Liedholm, 1979; Phongpaichit, 1982; Islam, 1984; Haggblade, Hazell and Brown, 1989; Figueroa, 1982; Luzuriage and Zuvekas, 1983).

The rural nonfarm economy plays an important, although variable, equity-enhancing role across countries. Landless and near-landless households everywhere depend on nonfarm earnings; those with less than 0.5 ha typically earn

TABLE 1

Share of the rural labor force primarily employed in nonfarm activities[a]

	Africa	Asia	Latin America
Percent of total employment			
Rural settlements[b]	14	26	28
Rural towns[c]	59	81	85
Rural settlements plus rural towns			
Total	19	36	47
Male[d]	16	37	36
Female[e]	19	34	79
Employment density per 1000 population			
Rural settlements[b]	50	83	79
Rural towns[c]	187	238	245
Rural settlements plus rural towns			
Total	65	121	129
Male[d]	35	90	87
Female[e]	30	31	42

Source: Population censuses for 43 countries (14 in Africa, 14 in Asia, and 15 in Latin America), all those for which employment data could be broken out by locality, size and sex. References available on request.

[a]Includes all nonagricultural activity except mining, that is International Standard Industrial Classification activities 3-9.

[b]Rural definitions vary with individual country census definitions. As a general rule, rural settlements in Africa and Asia are those below 5000. In Latin America, the cutoff normally lies at 2500.

[c]Rural towns do not exceed 250 000.

[d]Male nonfarm employment divided, for percentages, by total male employment, for densities by total population.

[e]Female nonfarm employment divided, for percentages, by total female employment, for densities by total population.

over half their total income from nonfarm sources (for reviews, see Islam, 1984; Ho, 1986b; Kilby and Liedholm, 1986). Yet across income groups, no consistent pattern emerges (Ho, 1986b; Shand, 1986; Haggblade, Hazell and Brown, 1987), perhaps in part because of the very success of nonfarm earnings in elevating some of the would-be-poor to higher-income groups or, alternatively, because of difficulties in accurately measuring what are frequently equity-enhancing female nonfarm earnings (Simmons, 1976; Matlon et al., 1979).

But in absolute terms, nonfarm earnings, especially certain activities, regularly assume major importance for the rural poor (see Matlon et al., 1979; Hossain, 1987; Haggblade, Hazell and Brown, 1987; Romijn, 1987). Low-investment manufacturing and services – including food preparation and processing, weaving, pottery, domestic and personal services, gathering, and unskilled nonfarm wage labor – typically account for a greater share of income for the rural poor than for the wealthy. In contrast, wealthy households earn more from transport, commerce, and manufacturing activities such as milling and metal fabrication, which require sizeable investment. Women, relatively more active than males in nonfarm activities in Africa and Latin America (Table 1), dominate many of the equity-enhancing nonfarm activities such as food processing, beverage preparation, weaving, gathering, selling of prepared snack foods, and personal services.

3. Agriculture and changes in the rural nonfarm economy

3.1 Factors affecting change in the rural nonfarm economy

The density and composition of rural nonfarm activity varies considerably across continents (Table 1), across countries, and even across regions within individual nations. Thus, the Totonicapan region of eastern Guatemala specializes in textile production; while other regions concentrate on handicrafts, with some hamlets even specializing by task (Smith, 1975, 1986). Northeast Thailand specializes in cloth production, largely because of seasonal release of labor from agriculture (World Bank, 1983). And brewers in rural Rwanda produce sorghum beer in the northwest region while banana wine predominates elsewhere, following the agricultural cropping patterns.

Differences in agriculture explain much – although by no means all – of the variation in rural nonfarm activity. On the demand side of the rural nonfarm economy, agriculture exerts a preponderant influence, since nonfarm enterprises depend primarily on the farm input and consumption demand of agricultural households. Driven largely by agricultural earnings, rural income levels determine the extent of consumer diversification into nonfoods. Moreover, land distribution affects income distribution and hence the share of incremental expenditure allocated to rurally supplied, as opposed to imported, nonfoods. Studies by King and Byerlee (1978), Hazell and Röell (1983) and Deb and Hossain (1984) suggest that larger-sized farms and higher-income groups generate the greatest consumption linkages with the rural nonfarm economy. Within these studies, high-income groups and farm sizes allocated the largest marginal budget shares to rurally produced nonfoods. But with their largest farm sizes between 5 and 15 ha, none of these studies included wealthy estate-owners. Nor have any other studies, although such estates are generally believed to spend a high proportion of their income on imported goods.

Demand for production inputs also varies across agricultural zones. Irrigated agriculture demands considerably more inputs than rainfed cultivation, while mechanized and animal traction systems require more tools, equipment and repair services than do hand-hoe cropping systems.

Agriculture likewise influences the supply side of the rural nonfarm economy, primarily through the labor market. Wages in agriculture set the opportunity cost of labor directed to nonfarm activities, while seasonality of labor demand in agriculture affects the supply of labor available for nonfarm endeavors. Further influencing supply, the composition of agricultural output furnishes raw materials which rural producers can transport, transform or market. Weight-reducing processes such as sugar and oil extraction frequently require rural processing. For this reason, sugar and oilseed cropping patterns generate distinctive regional clustering of rural processing activities (World Bank, 1983; Hossain, 1987; Papola, 1987).

But agriculture does not unilaterally govern the size, composition and evolution of the rural nonfarm economy. Operating primarily on the supply side, non-agricultural factors such as policy environments, infrastructure, human capital, caste, tradition, and the availability of nonagricultural raw materials all influence the nature of rural nonfarm activity. Thus, since 1977 employment in Sri Lanka's handloom industry, its largest rural manufacturer, has fallen by 50% as a result of economic liberalization which reduced former high rates of protection (Osmani, 1987). Conversely, rural rice mills have expanded rapidly in Thailand since the 1940s, following closely on the heels of rail penetration into the rural regions (World Bank, 1983).

3.2 Effects of agricultural growth on the rural nonfarm economy

A small but growing array of empirical work has begun exploring the relationship between changes in agriculture and changes in the rural nonfarm economy. The cross-country data in Fig. 1 depict a strong correlation between agricultural income and the size of the rural nonfarm economy. Charting the increasing importance of rural nonfarm activity as one moves from Africa to Asia to Latin America, Fig. 1 also documents the close connection between nonfarm activity and the development of rural towns. As the contrast between panel A and B reveals, measuring the nonfarm spinoffs of agricultural growth requires inclusion of the many that take root in rural towns (see also Gibb, 1974; Anderson and Leiserson, 1978; Haggblade, Hazell and Brown, 1987). These correlations are consistent with the notion that agricultural income growth leads to consumption diversification into nonfoods, many of which can be supplied by rural firms. Yet one cannot necessarily infer causality from these associations, since investments in infrastructure, introduction of improved agricultural technologies, rural income growth and increases in rural nonfarm incomes all frequently move in tight parallel.

Time-series evidence from countries with fast-growing agriculture suggests, however, that agriculture may generate powerful growth linkages. East Asia, in particular, has sparked keen interest, as many observers have asked why rural nonfarm activity has flourished in Japan and Taiwan in the post-WWII period, while in South Korea it has not. In 1980, farm households in Japan and Taiwan earned 80 and 65%, respectively, of their income from off-farm sources, three-fourths of it in high-paying wage employment in rural towns and urban areas. Yet Korean farmers earned only 33% of their total household income

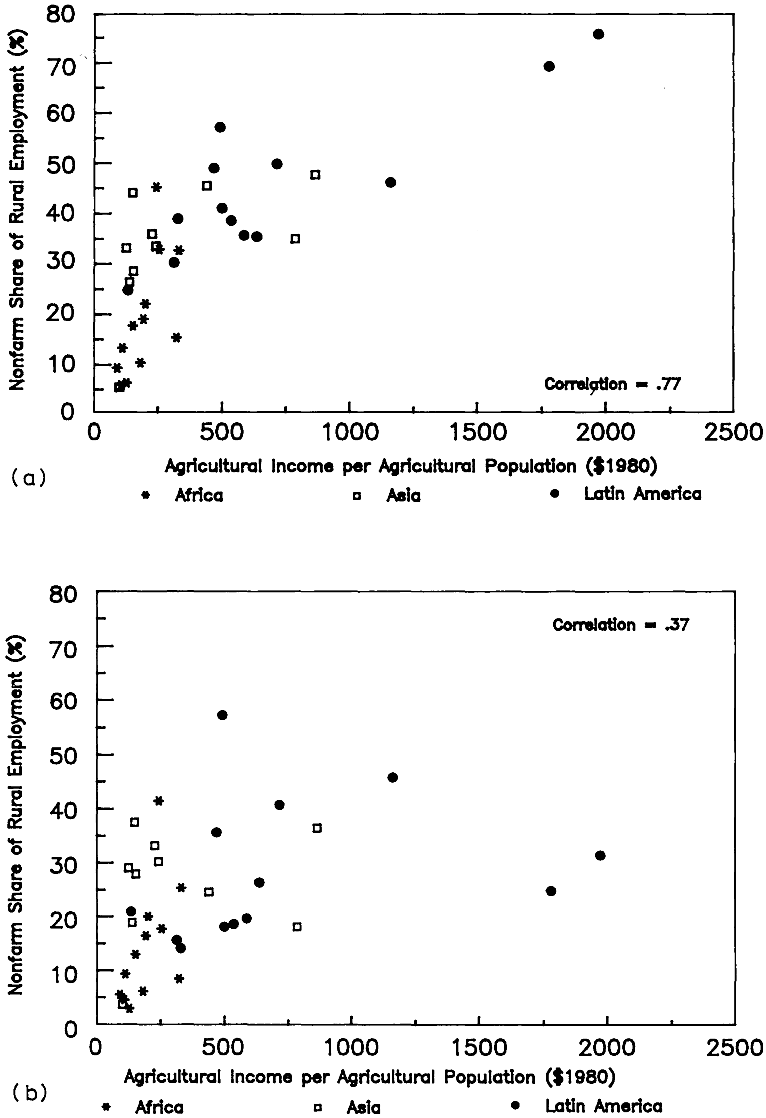

Fig. 1. Rural nonfarm employment as a function of agricultural income: (a) rural areas plus rural towns ⩽250 000; (b) rural areas only.

from nonfarm sources (15% if remittances are excluded), with less than half in wage-employment (Ho, 1986a; Oshima, 1986a; Park, 1986). Nor has the occupational structure of Korea's rural economy changed significantly in the past decade (Park, 1986), while Japan and Taiwan, on the other hand, have witnessed rapid increases in the rural nonfarm employment and income shares (Ho, 1982; Shih, 1983).

In explaining this disparity, most analysts point first to differences in agricultural performance (see Ho, 1979, 1982, 1986a,b; Kada, 1986; Oshima, 1986a, b; Park, 1986; Saith, 1987). They identify lower initial agricultural productivity in Korea, a relative neglect of agriculture and its consequently lower growth, particularly since 1970. Weaker agricultural growth diminished rural consumption linkages in Korea and at a later stage restricted the prospects for labor release from agriculture to high-paying, full-time, off-farm employment.

In addition to more rapidly growing agricultural incomes, Japan and Taiwan invested more heavily in rural roads, railroads and electricity and adopted a policy environment supportive of dispersed manufacturing, commercial and service activity. By the early 1960s, Japan and Taiwan boasted a paved road and rural electrical network with densities over five times those in Korea (Saith, 1987). Rather than following suit, South Korea concentrated its industrial infrastructure in Seoul and Pusan.

In other regions of the world, many observers fear the prospects for similar growth in high-return nonfarm activity are much less favorable (Islam, 1984, 1987; Deshpande and Deshpande, 1985; Mukhopadhyay, 1985; Ho, 1986b; Shand, 1986). Given greater landlessness in South Asia, Southeast Asia and Latin America, they fear that employment prospects in agriculture will not keep pace with population growth. Consequently, the rural nonfarm economy will become an employer of last resort, a sponge, absorbing by default labor force increments unemployed in agriculture into progressively lower and lower return nonfarm activities.

Yet the limited evidence emerging from Latin America, South and Southeast Asia suggests that even where landlessness and tenancy exist, agricultural growth can stimulate not only greater rural nonfarm employment, but also growing nonfarm incomes because of a diversification into higher-return nonfarm activity. Time-series studies from prosperous agricultural regions in Colombia (Reinhardt, 1987), The Philippines (Gibb, 1974), the Indian Punjab (Chadha, 1986), North Arcot, India (Hazell and Ramasamy, 1988), Malaysia (Bell, Hazell and Slade, 1982) and Thailand (World Bank, 1983) describe changes in the rural economy which suggest that rising agricultural wage earnings and growing consumption demand from farm households have stimulated increases in rural nonfarm employment, incomes and a move to more lucrative nonfarm activity.

Rural labor markets play a key role in shifting the composition of rural nonfarm activity. Providing it increases the demand for labor, agricultural growth increases rural wage earnings and the opportunity cost of labor, thereby making low-return nonfarm activities uneconomic.[1] Hossain (1988), in a recent study of the impact of green revolution technologies in Bangladesh, has documented this interaction explicitly. In villages with a majority of rice cropped in high-yielding varieties, he identifies higher agricultural incomes, higher agricultural wages and higher nonfarm income per capita compared to villages still dependent on traditional varieties. The higher nonfarm income in prosperous villages reflects a greater concentration of high-return nonfarm activity (transport and services) and less low-wage cottage industry, construction and earth hauling. Consistent with these findings, cross-regional studies from rural India (Papola, 1987), Togo and Sierra Leone (Haggblade, Hazell and Brown, 1987) show a positive correlation between earnings per worker in agriculture and in rural nonfarm activities.

Slow-growing agricultural regions have enjoyed less careful scrutiny. Yet a consistently heavy dependence of landless on nonfarm activity, coupled with the contrast between South Asia's low-return rural cottage industries, and the decentralized high-wage factory production in East Asia, is leading to a growing consensus that prospects for an expanding, remunerative rural nonfarm economy depend heavily on agricultural growth (Chuta and Liedholm, 1979; Anderson and Leiserson, 1980; Islam, 1984, 1987; Deshpande and Deshpande, 1985; Ho, 1986b; Mukhopadhyay, 1985; Shand, 1986).

4. Modeling agricultural growth linkages under alternative technologies

Research and extension policies will affect the type of technological change achieved in agriculture. And the different technologies will, in turn, alter the nonfarm economy in different ways. Modeling provides a convenient means of isolating the key impact of alternative technologies on rural nonfarm activity.

4.1 Basic assumptions

The model developed below depicts a simplified regional economy in which the main agricultural outputs – food or cash crops – are tradable but specialty and perishable agricultural commodities and all nonfood goods and services are classified as nontradables. While available technology limits tradable ag-

[1]Note that the move out of low-return activities does not necessarily require that agricultural wage rates increase, but only that agricultural wage earnings per worker increase. The distinction is important because while many yield-increasing technologies do lead to increases in the total number of days of hired labor employed in agriculture, the supply of labor is often sufficiently elastic that daily wage rates do not increase. But from the point of view of the individual worker, if he/she can obtain more days of agricultural employment at times when they were previously underemployed, then they will divert labor from lower paying activities.

ricultural output,[2] the supplies of nontradables are highly elastic, their output constrained by local demand. The prices of all tradables are taken as exogenous to the region, and this assumption in conjunction with the perfectly elastic supply of nontradables implies that the prices of nontradables are also fixed.

As improved agricultural technology becomes available it increases agricultural output and hence the demand for regional nontradables. In this stylized view of the rural economy, variations in agricultural technology lead to different rural growth linkages to the extent the input demand and the consumption patterns they generate differ. Consequently, key features of agricultural technology affecting the projected size of rural nonfarm spinoffs include: (a) the quantity of farm inputs required; (b) their sophistication, thence the ability of rural entrepreneurs to supply them; (c) the agricultural income (value added) generated; and (d) the divisibility of the technology, which affects the distribution of incremental earnings among income groups.

The assumption of elastic supply of nonfood nontradables seems reasonable given the available evidence on excess capacity in nonfarm production, low incremental capital–output ratios, and the seasonal availability of labor at low wages during slack periods in the agricultural calendar (Anderson and Leiserson, 1978; Liedholm and Mead, 1987). The parallel assumption for nontradable foods also approximates reality given that specialty agricultural production is not tied to the same seasonal cycle as tradable agricultural production, so much of its labor requirements can be met during periods when there is surplus agricultural labor.

While capturing several key features of agricultural-nonfarm interactions, the model advanced below faces several limitations. First, it is a static equilibrium approach that ignores the growth effects of additional investment. Moreover, by treating investment expenditures as exogenous, part of the difference in demand linkages arising from farms of different types and size may be lost. Second, the model does not incorporate any explicit specification of the labor market, and thus does not allow exploration of the changes in worker productivity that may accompany growth in nonfarm activity induced by agricultural growth.[3] Third, the model describes a self-contained regional economy and in

[2]A technology constraint necessarily implies an underlying resource constraint that is binding. In most cases, this is land, and yield-increasing technologies are required to relax the land constraint. But in some cases seasonal labor bottlenecks may be more binding, as in the less populated areas of sub-Saharan Africa, or irrigation water may be more critical as in some parts of Asia. In these cases, relevant technologies may involve mechanization or improvement in irrigation infrastructure.

[3]Since most nontradables are thought to be labor-intensive, assuming their supplies to be perfectly elastic implicitly assumes that the supply of labor is also highly elastic, and that wage rates therefore remain constant. This is consistent with the notion of increasing productivity per worker if, as argued earlier, technological change increases employment opportunities in agriculture and enables agricultural laborers to give up low-productivity nonfarm activities. Hossain (1988) has documented just such a shift in Bangladesh.

so doing ignores spillovers to or from major urban areas.[4] Fourth, by assuming highly elastic supplies of nontradables, the model may lead to overestimates of the size of the multipliers, especially in labor-scarce situations. With these caveats in mind, we now turn to a formal statement of the model.

4.2 The Model

A three-sector variant of the semi-input-output model developed by Bell and Hazell (1980), the model describes a rural economy in which regional gross output includes tradable output T, assumed to be fixed at $\bar{T}$, plus nontradable nonfoods, N, and nontradable agricultural output, A. Since the supply of N and A is assumed to be highly elastic, their output is determined by local demand. Local demand includes household consumption demand for nontradables (H), regional producers' intermediate demands for nontradables (P), government expenditures on nontradables (G), and regional investment demand for nontradables (I).

Household consumption expenditures on nontradables are assumed to be linearly related to income as follows:

$$H_A = \alpha_{oA} + \beta_A(Y - S) \qquad (1)$$

$$H_N = \alpha_{oN} + \beta_N(Y - S) \qquad (2)$$

where Y is total household income, S is total savings, the α's are constants, and β_A and β_N are, respectively, the marginal budget shares for nontradable foods and nonfoods. Savings are assumed to be proportional to income:

$$S = sY \qquad (3)$$

where s is the marginal propensity to save.

In Leontief fashion, intermediate demands for nontradables are assumed to be proportional to sectoral gross outputs, so that:

$$P_A = a_{AT}T + a_{AA}A + a_{AN}N \qquad (4)$$

$$P_N = a_{NT}T + a_{NA}A + a_{NN}N \qquad (5)$$

where a_{ij} denotes intermediate deliveries from sector i to sector j.

Finally, assuming that government and investment demands for nontradables are exogenously given ($G_A = \bar{G}_A$, $G_N = \bar{G}_N$, $I_A = \bar{I}_A$ and $I_N = \bar{I}_N$), the output of nontradables is determined as follows:

[4]Spillover effects arise because imports into the regional economy may create jobs and income elsewhere in the nation. Similarly, while savings that are invested outside the region represent a loss to regional growth, they are nevertheless valuable in furthering national economic growth. Conversely, regional growth may incur costs elsewhere in the economy. To capture these spillover effects requires a general equilibrium modeling approach such as that used by Byerlee for Nigeria (Byerlee, 1973) and Sierra Leone (Byerlee et al., 1977) and by Adelman (1984) for South Korea.

$$A = H_A + P_A + \bar{I}_A + \bar{G}_A \tag{6}$$

$$N = H_N + P_N + \bar{I}_N + \bar{G}_N \tag{7}$$

To complete the model, it is necessary to define household income Y. Assuming that (a) value added is a constant share of gross output in each sector (i.e. $v_j = VA_j / GO_j$ is constant, $j = T$, A and N), and (b) all value added accrues to households, then:

$$Y = v_T \bar{T} + v_A A + v_N N \tag{8}$$

Substituting all the assumed relations into (6) and (7) and collecting terms, the output of nontradables becomes:

$$A = \delta_A + (1-s)\beta_A v_A A + (1-s)\beta_A v_N N + a_{AA} A + a_{AN} N \tag{9}$$

$$N = \delta_N + (1-s)\beta_N v_A A + (1-s)\beta_N v_N N + a_{NA} A + a_{NN} N \tag{10}$$

where

$$\delta_A = \alpha_{oA} = [(1+s)\beta_A v_T + a_{AT}]\bar{T} + \bar{I}_A + \bar{G}_A$$

and

$$\delta_N = \alpha_{oN} + [(1-s)\beta_N v_T + a_{NT}]\bar{T} + \bar{I}_N + \bar{G}_N$$

Solving for A and N:

$$A = \frac{1}{D}[1 - a_{NN} - (1-s)\beta_N v_N]\delta_A + \frac{1}{D}[a_{AN} + (1-s)\beta_A v_N]\delta_N \tag{11}$$

$$N = \frac{1}{D}[a_{NA} + (1-s)\beta_N v_A]\delta_A + \frac{1}{D}[1 - A_{AA} - (1-s)\beta_A v_A]\delta_N \tag{12}$$

where

$$D = [1 - a_{AA} - (1-s)\beta_A v_A][1 - a_{NN} - (1-s)\beta_N v_N] - [a_{AN} + (1-s)\beta_A v_N][a_{NA} + (1-s)\beta_N v_A]$$

Suppose now that technological change in agriculture enables the region to increase its output of tradables. What will be the multiplier impact on the region's income? Using (8), the derivative:

$$\frac{\mathrm{d}Y}{\mathrm{d}\bar{T}} = v_T + v_A \frac{\partial A}{\partial \bar{T}} + v_N \frac{\partial N}{\partial \bar{T}} \tag{13}$$

measures the change in regional income for a unit change in the value of tradable agricultural gross output. The value added multiplier, which standardizes (13) for differences in the value added to gross output ratio in tradables production, is obtained as:

$$\frac{1}{v_T}\frac{\mathrm{d}Y}{\mathrm{d}\bar{T}}=1+\frac{v_A}{v_T}\frac{\partial A}{\partial \bar{T}}+\frac{v_N}{v_T}\frac{\partial N}{\partial \bar{T}} \tag{14}$$

The multiplier measures the increase in regional value added given a one-unit increase in value added from tradable agricultural output. Note that the increase in value added in the nontradable sector has two components; $(\partial A/\partial T)(v_A/v_T)$ is the increase in value added in nontradable agricultural production (typically fresh fruits, vegetables and some livestock products), and $(\partial N/\partial T)(v_N/v_T)$ is the increase in value added in nonagricultural nontradables:

The values of $\partial A/\partial \bar{T}$ and $\partial N/\partial \bar{T}$ are obtained from (11) and (12) as follows:

$$\begin{aligned}\frac{\partial A}{\partial \bar{T}}=&\frac{1}{D}[1-a_{NN}-(1-s)\beta_N v_N][(1-s)\beta_A v_T+a_{AT})\\&+\frac{1}{D}[a_{AN}+(1-s)\beta_A v_N][(1-s)\beta_N v_T+a_{NT}]\end{aligned} \tag{15}$$

and

$$\begin{aligned}\frac{\partial N}{\partial \bar{T}}=&\frac{1}{D}[a_{NA}+(1-s)\beta_N v_A][(1-s)\beta_A v_T+a_{AT})\\&+\frac{1}{D}[1-a_{AA}-(1-s)\beta_A v_A][(1-s)\beta_N v_T+a_{NT}]\end{aligned} \tag{16}$$

In addition to projecting aggregate regional income multipliers, the model can be used to isolate the importance of the household consumption linkages relative to the interindustry (or production) linkages in the multiplier. By setting the β coefficients equal to zero, household consumption expenditure becomes constant in the model. The derived multiplier arising from agricultural growth will then be due entirely to production linkages.

4.3 Size of the multiplier

Twelve key parameters determine the size of the multiplier for a regional economy. They are the marginal budget shares for nontradables in household expenditure (β_A and β_N), the marginal propensity to save (s), the ratios of nontradable intermediates to gross output in sectoral production (a_{AT}, a_{AA}, a_{AN}, a_{NT}, a_{NA} and a_{NN}), and the ratio of value added to gross output in sectoral production (v_T, v_A and v_N). If these parameters are known, the model can project the size of the indirect multiplier benefits deriving from agricultural growth in a region.

In Table 2 a variety of data sources have been used to estimate model parameters for some important types of agriculture and technology found in Asia, Africa and Latin America. The Asia estimates draw heavily on the social accounting matrices (SAMs), available for the Muda region in Malaysia (Bell,

TABLE 2

Value of the regional value-added multiplier under different assumptions about key parameters for a regional economy

	Value of model parameters[a]						Size and composition of multiplier				Multiplier with consumption exogenous	Percent multiplier due to consumption linkages[b]
	β_A	β_N	s	v_A	v_T	a_{NT}	T	A	N	Total		
Asia												
Irrigated rice, HYVs												
- small farms	0.05	0.30	0.1	0.7	0.8	0.1	1.00	0.06	0.49	1.55	1.12	78.2
- medium farms (average savings)	0.05	0.40	0.2	0.7	0.8	0.1	1.00	0.06	0.58	1.64	1.12	81.2
- medium farms (low savings)	0.05	0.40	0.1	0.7	0.8	0.1	1.00	0.07	0.67	1.74	1.12	83.7
Irrigated rice, all farms												
- traditional varieties (oxen)	0.05	0.25	0.1	0.7	0.9	0.05	1.00	0.05	0.33	1.38	1.06	84.2
- HYVs (oxen)	0.05	0.35	0.2	0.7	0.8	0.1	1.00	0.06	0.50	1.56	1.12	78.5
- HYVs (tractors)	0.05	0.35	0.2	0.7	0.65	0.08	1.00	0.06	0.50	1.56	1.12	78.5
Africa												
Rainfed, smallholders												
- hoe cultivation	0.1	0.15	0.1	0.8	0.95	0.02	1.00	0.10	0.18	1.28	1.03	89.3
- oxen cultivation	0.15	0.20	0.1	0.8	0.85	0.05	1.00	0.17	0.30	1.47	1.06	87.2
Rainfed, estates												
- low local consumption	0.05	0.1	0.3	0.8	0.6	0.08	1.00	0.05	0.20	1.25	1.13	48.0
- high local consumption	0.15	0.2	0.3	0.8	0.6	0.08	1.00	0.14	0.30	1.44	1.13	70.5
Latin America												
Rainfed, smallholders	0.05	0.25	0.1	0.7	0.9	0.02	1.00	0.05	0.30	1.35	1.03	91.4
Rainfed, estates												
- low local consumption	0.05	0.1	0.3	0.7	0.6	0.09	1.00	0.05	0.21	1.26	1.15	42.3
- high local consumption	0.05	0.35	0.3	0.7	0.6	0.09	1.00	0.05	0.47	1.52	1.15	71.2

[a]In all cases, $a_{AA}=a_{AT}=a_{AN}=0.01$; $a_{NA}=0.05$; $a_{NN}=0.1$; $v_N=0.8$.

[b]Calculated as $(M_c-M)/(M_c-1)\times 100\%$ where M_c and M are the multipliers calculated with consumption specified endogenously and exogenously, respectively.

Hazell and Slade, 1982) and North Arcot in South India (Hazell and Ramasamy, 1988). The consumption parameters, the β's, for Asia are based on Hazell and Roell (1983), Hazell and Ramasamy (1986) and Hossain (1988).

Production parameters for Africa and Latin America draw on published farm management data, especially Ruthenberg (1980). The African β's come from King and Byerlee (1978) and Hazell and Röell (1983), while those for Latin American smallholders are simply extrapolated from Asia. In the absence of any consumption studies examining the locational composition of rural consumption demand for estate households, it has been necessary to project probable lower and upper bounds for the β's.

The multipliers in Table 2 range in size from 1.25 to 1.74. That is, each dollar of additional value added generated in tradable agricultural output stimulates an additional US$0.25 to US$0.74 of value added in regional nontradables production. Irrigated rice regions in Asia growing HYVs generate the largest multipliers, while traditional smallholder regions under rainfed conditions in Africa and Latin America produce the smallest multipliers (about 1.3). The multipliers associated with estate agriculture range between the above extremes and depend critically on the assumed local content of estate household consumption expenditure.

As a check on the reliability of the model, it is useful to compare the Asian multipliers in Table 2 with the more careful estimates provided by Bell, Hazell and Slade (1982) for the Muda region in Malaysia, and by Hazell and Ramasamy (1988) for the North Arcot region in South India. In both study regions, historically observed changes in the output of agricultural tradables projected multipliers of 1.83, slightly higher than those in Table 2. But this difference arises because the full SAM projections allocated increased tradable output across a variety of sectors, not just paddy as in the Table 2 projections. Fortunately, Hazell and Ramasamy (1988) also report a value added multiplier derived specifically from an increase in paddy exports alone and, at US$1.67, this multiplier is very close to the results in Table 2.

Nonfarm activities account for a larger share of the total multiplier in Asia and Latin America than in Africa. For example, Table 2 shows that medium-sized, irrigated rice farms growing HYVs in Asia have a multiplier of 1.64. Of the US$0.64 indirect gain, US$0.58 (or 90%) accrues to producers of nonfarm nontradables and only US$0.06 accrues to producers of nontradable foods. In contrast, only US$0.18 (or 64%) of the total indirect gain of US$0.28 accrues to producers of nonfarm nontradables in rainfed areas of Africa dominated by hoe cultivating smallholders. The different structure of the multiplier arises because of a larger marginal budget share for nontradable foods in Africa. Hazell and Röell (1983) attribute this result to fewer towns and poor transport facilities, and consequently limited access to nonfoods in rural villages. Poor infrastructure development in Africa also fragments markets for perishable foods, thereby rendering nontradable foods that are tradables in Asia.

The consumption linkages account for some 80–90% of the total multiplier for all but estate agriculture according to Table 2. This supports Mellor's (1976) contention that Hirschman's (1958) omission of consumption linkages led to his unduly pessimistic indictment of agriculture as a low-linkage, underpowered engine of growth.

4.4 Effects of different agricultural technology

The results in Table 2 demonstrate that the choice of technology and farm type targeted by agricultural research and extension have important implications for the size of the multiplier.

Amongst HYV rice farms in Asia, the multiplier is greatest when technological change is focused on medium- rather than small-sized farms. If small- and medium-sized farms are assumed to have an identical savings rate of 0.1, then the multiplier is 1.74 for medium-sized farms and 1.55 for small-sized farms. Moreover, the multiplier for medium-sized farms remains larger, at 1.64, even when actual savings rates – which are twice as large for medium-sized farms – are assumed. This results from the stronger household consumption linkages of medium-sized farms; as Hazell and Röell (1983) and Mellor and Lele (1973) have noted, the β_N coefficients for medium-sized farms are larger.

Before concluding that agricultural development programs should target medium-sized farms, a number of important qualifications need to be made. First, the results assume that small- and medium-sized farms use the same scale-free technology. This is often the case for HYV rice in much of Asia, but where medium-sized farms are more mechanized, the extra employment they generate in the rural nonfarm economy might be offset by losses in direct employment in agriculture. Second, by holding investment constant, the model does not allow for possible differences in the nontradable content of investment expenditure by farm size group. The difference in the multipliers could be eroded if small farms invest greater shares of their savings locally than their medium-sized brethren. Third, the results are sensitive to the assumed supply elasticities in the model. If nontradables are less elastic in supply, or if the export demand for the region's tradables were inelastic, then the relative size of the multipliers might be reduced or reversed.

The choice between targeting estates or smallholders in Africa and Latin America is less equivocal. The estates generate smaller multipliers if, as seems reasonable, they have urbanized household expenditure patterns with low marginal budget shares for rural nontradables. Only if their expenditure patterns approach those of smaller-sized farms do the estates generate more favorable multipliers.

A comparison of traditional and high yielding varieties on Asian rice farms shows a larger multiplier for the HYVs (1.56 versus 1.38). Farms growing traditional varieties require fewer tradable inputs, and their ratios of value added to gross output are higher. But this positive contribution toward the multiplier is more than offset by lower household demand linkages as a result of lower incomes and smaller marginal budget shares for nontradables.

The choice of mechanization package (oxen versus tractors) does not affect the multiplier on Asian rice farms, although oxen cultivation does produce higher indirect income increments than hoe cultivation amongst Africa's smallholders. Greater mechanization increases the demand for nontradable intermediates in production (blacksmithing, machinery repair and servicing, etc.), and this adds to the size of the multiplier. At the same time, there is an almost exactly offsetting effect due to a decline in the value added generated per unit of output. The size of the multiplier therefore hinges on the strength of the household demand linkages. If mechanization leads to increased family incomes, and hence larger marginal budget shares for nontradables, the multiplier is larger. This seems to be the case with oxen cultivation in Africa, because it enables farmers to cultivate more land. But if mechanization simply involves a substitution of capital for labor without contributing much to total income – as is often the case with tractors in Asia (World Bank, 1987) – the multiplier is no larger than for less mechanized technologies.

5. Conclusions

Technological advance in agriculture generates substantial increases in rural income over and above the direct impact on agricultural earnings. These benefits are of the order of 25 and 75 cents for each $1.00 of value added generated directly in agriculture.

Because consumption linkages account for over 80% of the indirect income increments, the most important features of agricultural technology are those affecting income distribution and hence consumption patterns. Input divisibility emerges as most important because of the prospects it offers for widespread distribution across income classes. In general, this suggests that biological improvements will yield greater indirect income benefits than will mechanical innovations. Middle-sized farms appear to generate the greatest rural growth linkages because of greater demand diversification into nonfarm goods compared to small farms and because of lower import content than estate farms, although this final surmise will require confirmation once careful large-farm consumption profiles become available.

Through the labor market, agricultural growth also influences rural wage rates and hence the supply side of the rural nonfarm economy. Empirical studies suggest that labor-using agricultural growth can effectively foster a move to high-return nonfarm activities.

While the type of technological change influences the relative size of the multiplier, its absolute size is largely controlled by the policy, institutional and resource environment in which agricultural production takes place. The multipliers tend to be smaller in Africa, for example, probably as a reflection of poorer rural infrastructure, lower population density, lower income and consequently less consumer diversification into nonfoods, fewer prospects for irrigation and therefore fewer backward linkages than other regions. Because appropriate public policies and investments will play a key role in enhancing the strength of the indirect benefits of agricultural growth, they should be seen as playing a complementary role to investments in agricultural research.

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