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Technology Choice and Income Distribution

JEFFREY JAMES
Tilburg University, Tilburg, The Netherlands

and

HAIDER KHAN*
University of Denver, Colorado, U.S.A.

Summary. — Whereas the macroeconomic relationship between technology choice and income distribution has so far been studied in the agricultural context, this paper studies the issue from the standpoint of manufacturing industry. We suggest that there are historical reasons why labor-intensive techniques tend to be more egalitarian in their impact than capital-intensive techniques. These hypotheses are tested by means of a disaggregated SAM for Indonesia and with the assistance of structural path analysis. In general the empirical analysis confirms our theoretical expectations. © 1997 Elsevier Science Ltd. All rights reserved

Key words — technology, income distribution, Indonesia, Asia

1. INTRODUCTION

Within the context of the agricultural sector one can point to numerous attempts to assess the macroeconomic effects of alternative technologies on the distribution of income. One of the most influential early efforts, for example, was undertaken mainly in the Indian context by John Mellor (1976), who was seeking to redefine agriculture's role in development strategy and policy. In rejecting the then existing capital-intensive and industry-led development model and advocating instead, a rural-led, employment-intensive path to development, Mellor was concerned, among other things, with the relationships between increased foodgrain production using alternative technologies and the growth rate of nonagricultural employment, nonagricultural sector capital–labor ratios and the course of per capita incomes of the labor force. More recently, Haggblade and Hazell (1989) have used an input–output based model to examine how differences in the choice of agricultural technology and farm size influence the indirect (or multiplier) effects of increases in agricultural output. They show, for example, that "The input intensity, consumption profile of targeted farms and processing characteristics of the farm output all affect the size and composition of nonfarm spinoffs" (Haggblade and Hazell, 1989, p. 346). The finding that consumption linkages generally dominate the total multiplier confirms Mellor's (1976) emphasis on the importance of this particular type of linkage effect.

In the area of nonagricultural technology and development, by contrast, the relationship between technological choice and income distribution has been largely neglected. To a degree, this reflects the fact that the literature is overwhelmingly microeconomic in character and is therefore able, by its very nature, to capture only the direct effects of alternative technologies on the distribution of income. The indirect or feedback effects, which, in practice, tend to be far more important, need to be estimated within a macro rather than a microeconomic framework. The problem, however, is that this is difficult to accomplish on the basis of most existing macroeconomic models, because these do not usually differentiate between alternative technologies and products. Some way needs to be found, therefore, of incorporating microeconomic technological data into these models, which would then be capable of estimating the indirect as well as the direct effects of alternative technology choices on the distribution of income.

If we are substantially to improve our understanding of the topic, however, we cannot confine ourselves only to the empirical issue, for there is also a need to provide an analytical framework that can be used to interpret the findings from the thus improved methodology. This paper, accordingly, has a dual

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objective: the first being to provide a general discussion of the differential effects on the distribution of income that can be expected from traditional as opposed to relatively modern technologies. The paper then shows how this framework can be used to understand the short-run distributional impact of alternative sugar processing technologies in Indonesia, as estimated within a modified social accounting matrix (SAM).

2. THE ANALYTICAL FRAMEWORK

Production techniques can be said to embody a range of different characteristics, such as the type and nature of the product, the organization of production, raw material and labor inputs and the scale and location of production (Stewart, 1977). In orthodox economic theory, there is nothing that would suggest any systematic association between these various characteristics. Rather, one would expect a more or less random association of characteristics across techniques of varying labor-intensity.

An alternative view, however, is that different technologies form part of distinct technological systems and that within each such system predictable relationships emerge between the variables just mentioned.[1] The theoretical basis for such a view resides mainly in the Marxist notion of a mode of production, with its emphasis on the "systemic" aspects of societies and especially the interrelations between technology, property rights and preferences in each type of society (Richards, 1986). The mode of production, he suggested,

> is an internally balanced whole in which production relations, and especially the base on which they rest — the ownership of the means of production — are adjusted to the requirements of a given state of the development of social productive forces. We know that production relations cannot be arbitrary for given productive forces. A large industrial unit like an iron works or a locomotive factory, where a great number of people are employed using large and numerous specialized machines and technical installations, cannot exist in conditions of simple commodity production, where the ownership of the means of production is scattered among a very large number of individuals. Such a production unit requires either capitalist or socialist production relations (Lange, 1963, p. 21).

If a historical perspective thus helps to make a connection between the way production is organized, the type of technology and the scale of production, it also helps to provide associations between other characteristics of a production technology that were mentioned at the beginning of this section, thus further contributing to the idea that technology should be viewed in terms of a system rather than as a vector of isolated characteristics. Stewart (1977), for example, has shown how, at any point in time, techniques tend to be,

> developed against a background of a particular technology package[2] . . . Any single technical innovation has to fit in with the rest of the system both in terms of the requirements it imposes for inputs, and in terms of the demand for the goods. A new technique must use inputs that are available, or can be made available, and must provide output which will fit into further production if it is an intermediate good, or into consumption patterns if it is a consumer good.[3] . . . There are technological linkages between different parts of the system which mean that much of technology comes as a package, which cannot be separated and introduced bit-by-bit, but which goes together.[4]

In most developing countries, however, there is not one technological system; rather a range of systems can be identified with features that may often be highly disparate, reflecting the historical conditions at a particular point of time. At the one extreme, for example, are technological systems which represent the period of "precapitalist" economic formations. In these societies, the technological relationships within the system have a strong geographical component. Production and consumption activities, that is to say, tend to be closely related in a particular geographical location: "the greater part of the products are produced for the satisfaction of the immediate needs of the community not as commodities" (Marx, 1946, p. 377). This (typically rather isolated) locality would usually exhibit a heavy degree of reliance on unskilled labor and self-employment (or family labor) as the mode of production, and it would usually exhibit minimal links with external technological systems (put otherwise, there would be highly limited leakages out of the system, as occur, for example, when imports from other systems take place). Such a technological system, furthermore, tends to make intensive use of local labor and other inputs per unit of output (as one would expect in a system lacking modern technologies and advanced technological capabilities).

At the other extreme, the modern sector of most developing countries closely resembles the technological system that is found in developed countries. This means, among other things, production techniques that are associated with the following characteristics: high-income sophisticated products; high levels of investment per head; educated and skilled labor inputs; high levels of labor productivity; close links, via backward and forward linkages to the modern technological system (frequently via a heavy dependence on imported inputs from developed countries).

Table 1 juxtaposes these contrasting aspects of traditional and modern technological systems and it also shows the mechanisms through which these differences are likely to bear on the distribution of income. In some cases, for example, the differences bear on the direct and indirect employment effects that can be expected from traditional as opposed to

Table 1. *Alternative technology systems: modes of influence on income distribution*

	Traditional technology system	Modern technology system	Mode of influence on income distribution
(a)	Labor-intensive methods of production	Capital-intensive methods of production	Direct employment effect
(b)	Noncapitalist mode of production	Capitalist mode of production	Share of income accruing to factors of production
(c)	Dispersed small-scale production units	Production concentrated in small number of large-scale units	Dispersion of incomes across production units
(d)	Relatively high labor–output ratio throughout production chain	Relatively low labor–output ratio throughout production chain	Indirect employment effect
(e)	Relatively high nonlabor (input) to output ratio throughout production chain	Relatively low nonlabor (input) to output ratio throughout production chain	Backward linkages
(f)	Uses mainly inputs from own system	Uses mainly inputs from own system	Backward linkages
(g)	Relatively low (savings and import) leakages from the system	Relatively high (savings and import) leakages from the system	Linkages
(h)	Consumes a relatively high proportion of its own products	Consumes a relatively high proportion of its own products	Consumption linkages

modern technologies, while in other cases the differences bear on backward linkage effects or the dispersion of incomes across production units of varying sizes. Table 2 combines the information contained in each row of Table 1 into a set of eight propositions about the differential effects of traditional and modern technologies on the distribution of income.

3. THE SAM FRAMEWORK

The empirical analysis that is described below is based on a social accounting matrix (SAM), albeit one with certain distinctive features, and the presentation of the results relies heavily on the concept of fixed price multipliers. In order to understand the derivation of these fixed price multipliers let us consider the following schematic SAM where the accounts have been divided into endogenous and exogenous categories for modelling purposes.[5] In concrete terms, for the Indonesian case to be described below, the technology-*cum*-productive activities, factors and households are endogenous, the remainder of the domestic economy as well as the rest of the world are exogenous.

Table 2. *Alternative technology systems: implications for the distribution of income*

	Traditional technology system	Modern technology system
(a)	Generates high amount of direct employment	Generates low amount of direct employment
(b)	Relatively high percentage of value added accrues to rural self-employed, household family members	Relatively high percentage of value added accrues to (local and foreign) companies as profits
(c)	Wide geographical dispersion of income among small-scale units	Concentrated income generation among large-scale units
(d)	Generates high amount of indirect employment through backward linkage	Generates low amount of indirect employment through backward linkage
(e)	Generates relatively large backward linkage effects	Generates relatively small backward linkage effects
(f)	Linkages generated mainly within the traditional system	Linkages generated mainly within the modern system
(g)	Linkages within the system relatively unaffected by leakages	Linkages within the system subject to relatively substantial leakages
(h)	Consumption linkage to (traditional) products within the system	Consumption linkage to (modern) products within the system

Table 3. *Schematic representation of endogenous and exogenous accounts in a SAM*

	Expenditures				
	Endogenous	Sum	Exogenous	Sum	Totals
Endogenous	T_{nn}	n	Injections T_{nx}	x	y_n
Exogenous	Leakages T_{xn}	l	Residual balances T_{xx}	t	y_x
Totals	y_n		y_x		

Looking at Table 3, which represents a SAM, we can see immediately that

$$y = n + x \tag{1}$$

$$y = l + t \tag{2}$$

Now, if we divide the entries in the matrix T_{nn} by the corresponding total income (i.e., y_n), we can define a corresponding matrix of average expenditure propensities. Let us call this matrix A. We now have

$$y = n + x = Ay + x \tag{3}$$

$$y = (I - A)^{-1} x = M x \tag{3a}$$

M has been called the matrix of the accounting multipliers, because these multipliers, when computed, can account for the results (e.g., income, consumption, etc.) obtained in the SAM without explaining the process that led to them. Let us now partition the matrix A in the following way:

$$A = \begin{matrix} 0 & 0 & A_{13} \\ A_{21} & A_{22} & 0 \\ 0 & A_{32} & A_{33} \end{matrix}$$

Given the accounts factors, household, and production activities, we now see that the income levels of these accounts (call them y_1, y_2, y_3, respectively) are determined as functions of the exogenous demand of all other accounts. In this respect, what we have is a reduced-form model that can be consistent with a number of structural forms. This is satisfactory as far as tracing the effects of a certain injection in the economy is concerned, or for prediction purposes when the structural coefficients are more or less unchanged.

One limitation of the accounting multiplier matrix M as derived in Equation (3a) is that it implies unitary expenditure elasticities (the prevailing average expenditures propensities in A are assumed to apply to any incremental injection). A more realistic alternative is to specify a matrix of marginal expenditure propensities (C_n below) corresponding to the observed income and expenditure elasticities of the different agents, under the assumption that prices remain fixed. Expressing the changes in incomes (dy_n) resulting from changes in injections (dx) one obtains

$$\begin{aligned} dy_n &= C_n dy_n + dx \\ &= (I - C_n)^{-1} dx = M_c dx \end{aligned} \tag{4}$$

M_c has been coined a fixed price multiplier matrix, and its advantage is that it allows any nonnegative income and expenditure elasticities to be reflected in M_c. In particular, in exploring the macroeconomic effects of exogenous changes in the output of different commodities on other macroeconomic variables, it would be very unrealistic to assume that consumers reacted to any given proportional change in their incomes by increasing expenditures on the different commodities by exactly that same proportion (i.e., to assume that the income elasticities of demand of the various socioeconomic household groups for the various commodities were all unitary). Since the income elasticity is the ratio of marginal expenditure propensity (MEP_i) to the average expenditure propensity (AEP_i) for any given good i, it follows that the marginal expenditure propensity can be readily obtained once the income elasticity and the average expenditure propensities are known:

$$\varepsilon y_i = \frac{MEP_i}{AEP_i} \tag{5}$$

$$MEP_i = \varepsilon y_i AEP_i \tag{6}$$

$$\text{and} \quad \Sigma MEP_i = 1 \tag{7}$$

Thus, given the matrix A_{32} of average expenditure propensities, and the corresponding income elasticities of demand y_i, the corresponding marginal expenditure propensities matrix C_{32} could easily be derived.

Before moving on to the case study in the next section some special features of the above modeling procedure should be noted. As noted already this is a fixed price multiplier model which is appropriate for the short (or perhaps intermediate) run but not for the long run when prices are flexible. In economies such as Indonesia, however, the implications of short-run rigidities may be captured by the fixed-price approach.

A second, related aspect has to do with the value of the multipliers. At full employment the impact of an increase in demand will be reflected in prices, not output and employment. The operating assumption here is, therefore, that in many sectors there is excess capacity. Given the existence of open and disguised unemployment in Indonesia this is not an unreasonable assumption.

Finally, some remarks are in order for the kind of factor markets assumed in the model. For (short-run) wage rigidities to be an appropriate assumption labor market imperfections must be present. The data and the discussion published by the BPS (Indonesian Central Bureau of Statistics) indicate widespread wage rigidities in both agricultural and nonagricultural sectors. The Indonesian SAM was prepared by using this data base, thus the assumption of labour market imperfections would seem to be consistent with the institutional realities of Indonesia. It should also be noted that different households have different savings rates and capital markets are also imperfect.

Keeping the above features in mind the present model can be seen as a first approximation to the short-run effects of technology on income generation in Indonesia.

4. AN INDONESIAN CASE STUDY

As noted earlier, most macroeconomic models do not differentiate between alternative technologies and products and they are therefore incapable of capturing any differential distributional effects of such technologies. One exception to this general tendency, however, is the modified SAM framework for Indonesia, that Khan and Thorbecke (1988, 1989) refer to as SAM-TECH.

This framework is exceptional because it attempts to differentiate between technologies and products in six manufacturing sectors where a marked degree of technological dualism exists: sectors, in other words, where traditional and modern methods of production coexist. After distinguishing between these alternative methods of production in each of six manufacturing sectors (hand-pounded vs. milled rice, farm vs. plant-processed tea; dried and salted vs. canned fish; brown vs. refined sugar; canning and preserving of fruits and vegetables in small vs. medium and large firms; and clove vs. white cigarettes), Khan and Thorbecke were able to graft 12 new production activities onto the 1975 SAM for Indonesia. SAM-TECH is also disaggregated in terms of labor and household groups, containing, respectively, 16 and 10 such categories. As such, it is particularly suitable for testing the hypotheses advanced in Table 2. This could in principle be done for each of the six dualistic sectors just mentioned, but it would clearly have been an impossibly ambitious project for a single article. Accordingly, we have chosen to present the results for just one sector, sugar, in the substantial degree of detail that is necessary for an examination of the various hypotheses contained in Table 2.

(a) *Alternative sugar-processing technologies and household income distribution*

Table 4 shows the economy-wide income effects on the 10 household groups, of a unitary injection of exogenous demand for sugar produced on the basis of both traditional and modern technologies. That is, in the form of fixed price multipliers, the table shows the effects of a unitary injection of demand on the 10 household groups after all direct and indirect effects have been taken into account within the SAM.

An increase of one rupiah's worth of (brown) sugar produced by traditional technology, for example, would ultimately yield 0.192 units of income to households labeled agricultural employees and 0.342 units of income to households represented by small farms. Similarly, an increase of refined sugar by the same amount would yield 0.110 and 0.205 to these two groups, respectively.

The results contained in Table 4 are broadly consistent with our analytical framework in that the traditional technology benefits rural rather than urban households while the converse is true of the modern sugar technology. We also need to know, however, whether the economic mechanisms that underlie these results conform to what was suggested in Table 2 and the rest of the paper in fact is devoted to a discussion of these issues.

(b) *Direct and indirect employment effects on household groups*

Our earlier analysis of technological systems led us to conclude that direct and indirect employment effects would tend to be greater when traditional rather than modern technologies are used and we further suggested that in the former case, the effects would tend to occur in rural rather than urban areas. Table 5 throws a good deal of light on these issues because it contains estimates of total employment effects for 16 labor groups, when output of sugar is increased (by one million rupiahs) on the basis of both traditional and modern technologies.

Table 5 indicates that total employment is indeed greater when the traditional technique is used and it also reveals, as hypothesized, that the employment gains would be greatest in the rural labor categories. Among these, the categories of unpaid rural, paid rural and production unpaid rural feature especially prominently and it can be shown (from an analysis of fixed price multipliers), that much of the income that

Table 4. *Fixed price multipliers giving effects of alternative sugar processing technologies on household income distribution*

Households	Traditional technology	Modern technology
Agricultural employees	0.192	0.110
Farm Size 1	0.342	0.205
Farm Size 2	0.235	0.148
Farm Size 3	0.391	0.239
Rural Lower	0.405	0.246
Rural Middle	0.065	0.042
Rural Higher	0.138	0.094
Urban Lower	0.239	0.301
Urban Middle	0.038	0.042
Urban Higher	0.229	0.244
Total Household Income	2.275	1.666

Source: Khan and Thorbecke (1988).

accrues to these groups is distributed ultimately to the very household groups (such as rural lower) that were seen earlier to gain most from the use of traditional technology.[6] Thus, to at least some extent, the differential impact of alternative technologies on the distribution of income is attributable to the varying amounts of employment with which those technologies are associated.

(c) *Consumption linkages*

Consumption linkage refers to the extent to which income generated in a technological system is spent on goods emanating from within the same system.[7] Would, for example, the rural employment gains from using traditional technology that have just been mentioned, have the further favorable effect for the rural areas of stimulating the demand for products made in those same areas? Basing our argument partly on the Marxist notion of a mode of production, we suggested earlier that this type of linkage would indeed tend to be a potent one in both traditional and modern technological systems in developing countries (that is, that households in both systems would tend to consume a relatively high proportion of products emanating from within their own particular systems).

Consider from this point of view Table 6, which contains the marginal expenditure propensities for the products made by traditional and modern technologies in the six dualistic sectors mentioned earlier. Taking rural and urban households as belonging (in an approximate way) to traditional and modern technological systems, respectively, one needs to determine whether the expenditure propensities of the rural group of households are higher for traditional than modern goods and whether the converse applies to the urban households. For some of the product categories in the table, this is clearly the case. Agricultural and rural households, for example, favor traditional over modern cigarettes while urban households tend to exhibit just the opposite pattern of consumption behavior. Other cases, however, are more ambiguous. The consumption of tea, for example, behaves as expected with respect to rural households, but households in urban areas consume the same amount of both products.

Or again, though all urban groups consume more milled than hand-pounded rice, among rural households there is no single pattern of consumption behavior. Thus, the data do not provide unqualified support for our view of how income generated within different technological systems tends to be spent.

(d) *The economic separation of technological systems*

A more general version of the idea underlying consumption linkages is that economic activity as a whole tends to occur within rather than between technological systems (though of course there will always be some degree of interaction between them). This broader hypothesis can be examined in the context of SAM-TECH by means of the data contained in Table 7.

What is shown here is the extent to which a unitary increase in sugar demand (and output) influences economic activity in the traditional as opposed to the modern component of the five other dualistic sectors we have already referred to. Thus, while the traditional sugar processing technology has a much greater impact on the other traditional activities than does the modern technology, the converse does not hold true. The reason for this asymmetry is not clear to us.

Table 5. *Total employment effects of alternative technologies in the sugar industry*

	Effects on labor income of increase of 1 million rupiahs in output of				
Labor category	Brown sugar (fixed price multiplier)	White sugar (fixed price multiplier)	Average wages and salaries per worker equivalent (thous. rupiahs)	Employment (number of worker equivalents)	
Ag. paid rural	133	79	92.1	1.44	0.86
Ag. paid urban	5	3	101.0	0.05	0.03
Ag. unpaid rural	218	142	88.1	2.47	1.61
Ag. unpaid urban	9	6	113.5	0.08	0.05
Production paid rural	118	97	82.9	1.42	1.17
Production paid urban	49	69	121.3	0.40	0.57
Production unpaid rural	110	66	76.8	1.43	0.86
Production unpaid urban	17	18	—	—	—
Cler. paid rural	45	35	106.9	0.42	0.33
Cler. paid urban	61	59	191.1	0.32	0.31
Cler. unpaid rural	85	62	—	—	—
Cler. unpaid urban	46	35	—	—	—
Prof. paid rural	45	35	132.1	0.34	0.26
Prof. paid urban	57	51	723.3	0.08	0.07
Prof. unpaid rural	7	6	78.0	0.09	0.08
Prof. unpaid urban	21	18	—	—	—
Total				8.54	6.2

Source: Khan and Thorbecke (1988) and Central Bureau of Statistics, *Social Accounting Matrix Indonesia, 1975*, Vol. 1, 1982.

(e) *Structural path analysis of household income generation*

Further insights into the mechanisms underlying the results contained in Table 4 can be gained by using a technique known as structural path analysis. This technique is particularly well suited to explaining the distributional consequences of using alternative technologies, because it attempts to decompose the fixed price multipliers into a series of both direct and indirect influences (Defourny and Thorbecke, 1984; Khan and Thorbecke, 1988, 1989; Khan, 1991).

Each average expenditure propensity a_{ji} or marginal expenditure propensity c_{ji} can be interpreted as the magnitude of the influence transmitted from i to j. In our case it is the matrix of marginal expenditure propensities that captures the direct influence of the network of elementary paths.

Two complications arise in the transmission of these influences. First, in travelling between successive poles, as the number of poles increase the influence gets attenuated. The attenuation could be calculated simply by multiplying the corresponding MEP's were it not for a further complication. This second complication arises because of the presence of loops and circuits where a set of influences go round and round infinitely many times within a fixed number of poles. It is this second, convergent process which gives rise to the so-called path multipliers. The fixed price multipliers are called global influences. The decomposition of this global influence can now be expressed as follows:

$$I^{G}(i \rightarrow j) = m_{ji} = \sum_{p=1}^{n} I^{T}(i \rightarrow j) \tag{8}$$

$$= \Sigma\, I^{D}(i \rightarrow j)\, M_p$$

where $I^G(i \rightarrow j)$ = global influence from the I^{th} column in the SAM to the j^{th} row.
$I^T(i \rightarrow j)$ = Total influence from i to j.
I^D = Direct influence from i to j.
M_p = Path multiplier along the path p.

The above equation can now be used to analyze the effects of changes in output (in response to increased demand) in either brown sugar or white sugar on the incomes of all the household groups. Since it would be tedious to discuss all 20 influence graphs we have selected three groups for analysis here. (We chose one group to represent farming households, another to represent rural households and the third as representative of households from urban areas.) Figures 1–6 capture the structural paths for these groups, respectively. We

Table 6. *Household marginal expenditure propensities for Indonesia, 1975**

	Agric. employees	Farm size 1	Farm size 2	Farm size 3	Rural lower	Rural middle	Rural higher	Urban lower	Urban middle	Urban higher
Traditional sugar	0.006	0.008	0.006	0.004	0.004	0.005	0.004	0.002	0.002	0.001
Modern sugar	0.014	0.013	0.012	0.012	0.012	0.012	0.011	0.009	0.008	0.005
Handpounded rice	0.015	0.064	0.120	0.037	0.020	0.036	0.014	0.004	0.005	0.001
Milled rice	0.175	0.101	0.027	0.033	0.136	0.116	0.072	0.06	0.058	0.012
Farm processed tea	0.003	0.004	0.003	0.002	0.007	0.004	0.002	0.001	0.001	0.001
Processed tea	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Dried and salted fish	0.016	0.017	0.016	0.014	0.018	0.020	0.017	0.013	0.012	0.009
Canned fish	0.004	0.003	0.002	0.002	0.003	0.003	0.003	0.002	0.002	0.002
Traditional cigarettes	0.055	0.051	0.035	0.022	0.03	0.009	0.03	0.02	0.013	0.004
White cigarettes	0.00	0.00	0.005	0.009	0.013	0.019	0.008	0.012	0.008	0.010

*The marginal expenditure propensities for canning and preserving are zero throughout.
Source: Khan and Thorbecke (1988).

Table 7. *Aggregate effects of alternative sugar technologies on dualistic sectors using fixed price multipliers*

Technology	Aggregate effects on traditional dualistic sectors*	Aggregate effects on modern dualistic sectors†
Traditional	0.197	0.216
Modern	0.129	0.148

Notes: *Includes handpounded rice, farm processed tea, dried and salted fish, small-scale canning of fruit and vegetables, clove cigarettes.
†Includes milled rice, off-farm processed tea, canned fish, medium and large-scale canning of fruit and vegetables, white cigarettes.
Source: Khan and Thorbecke (1988).

now turn to a discussion of the influences shown by these particular graphs. (In interpreting them, one should bear in mind that at the origin of each arc the corresponding marginal expenditure propensity is given.)

The first two sets of path diagrams are very similar in at least two major respects. The first is that in both cases the two different technologies exert their influence through the same or very similar sets of paths. In the first figure, that is to say, the paths are identical while in the second figure there is only one extra path (connecting brown sugar to the group "clerical paid rural") that distinguishes brown from white sugar. The two figures are also very similar with regard to differences in the magnitude of the linkages that apply to the case of brown as opposed to white sugar. In both cases, that is to say, the main quantitative differences lie in the backward linkage to farm nonfood crops (that is, palm sugar and sugar cane for white and brown sugar respectively) and the

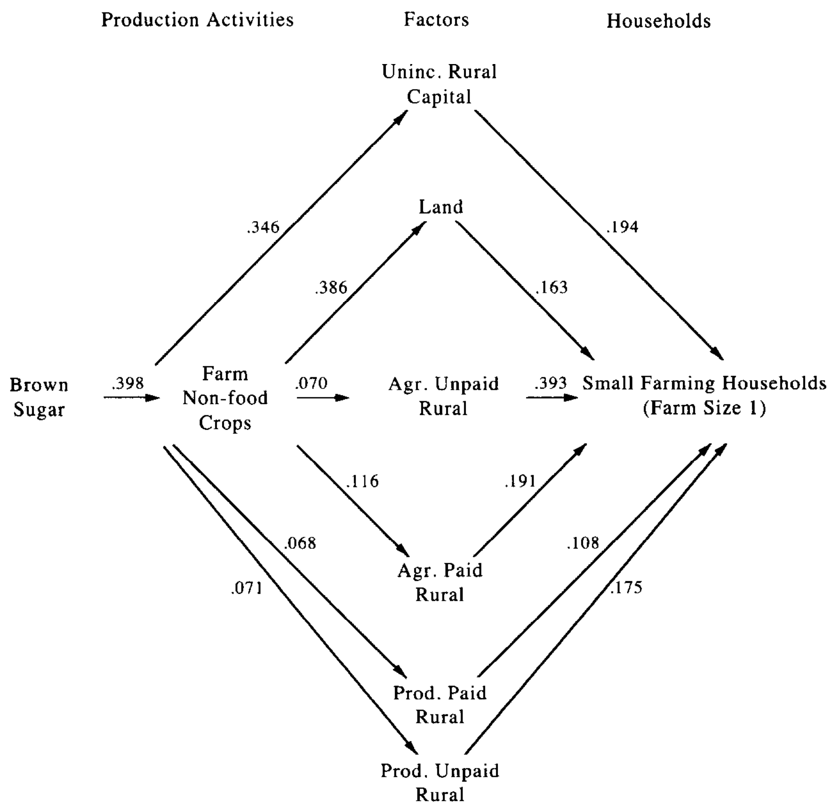

Figure 1. *Structural path network for the effects of brown sugar on small farming households. Source: Khan and Thorbecke (1988).*

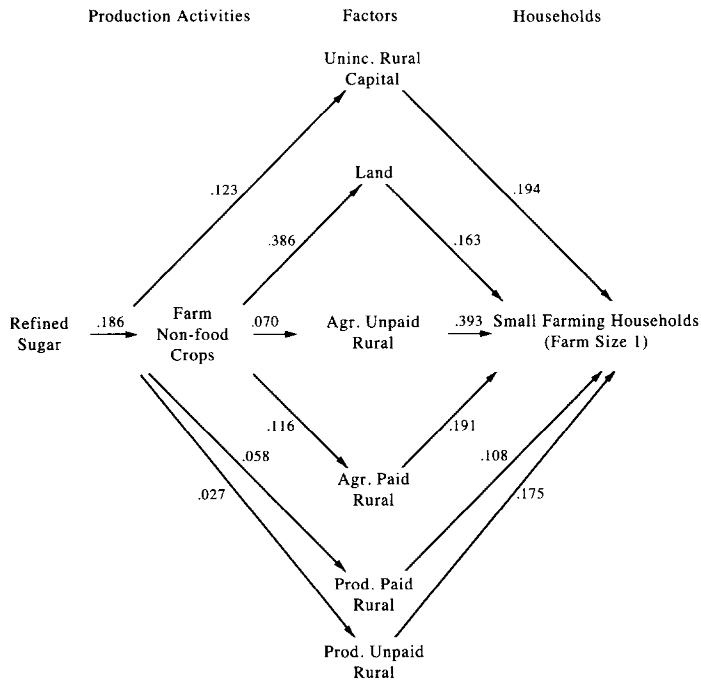

Figure 2. *Structural path network for the effects of refined sugar on small farming households. Source: Khan and Thorbecke (1988).*

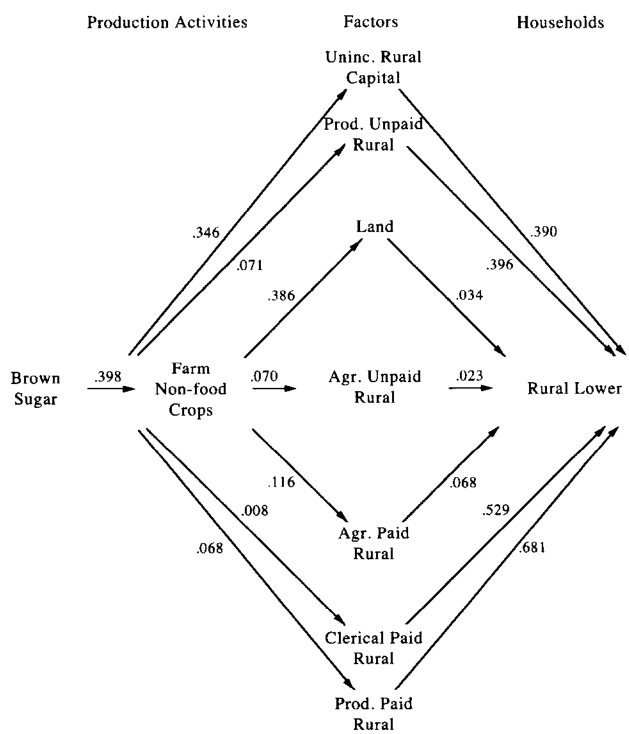

Figure 3. *Structural path network for the effects of brown sugar on the income of rural lower households.*

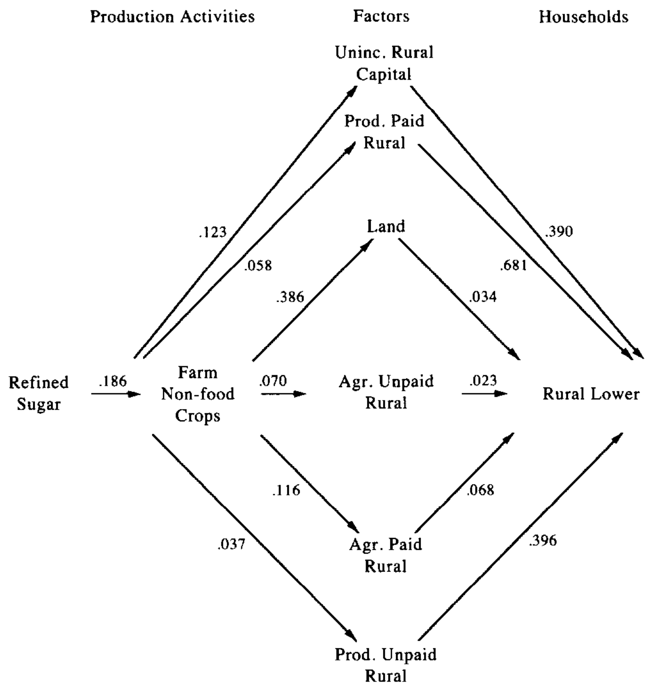

Figure 4. *Structural path network for the effects of refined sugar on the income of rural lower households.*

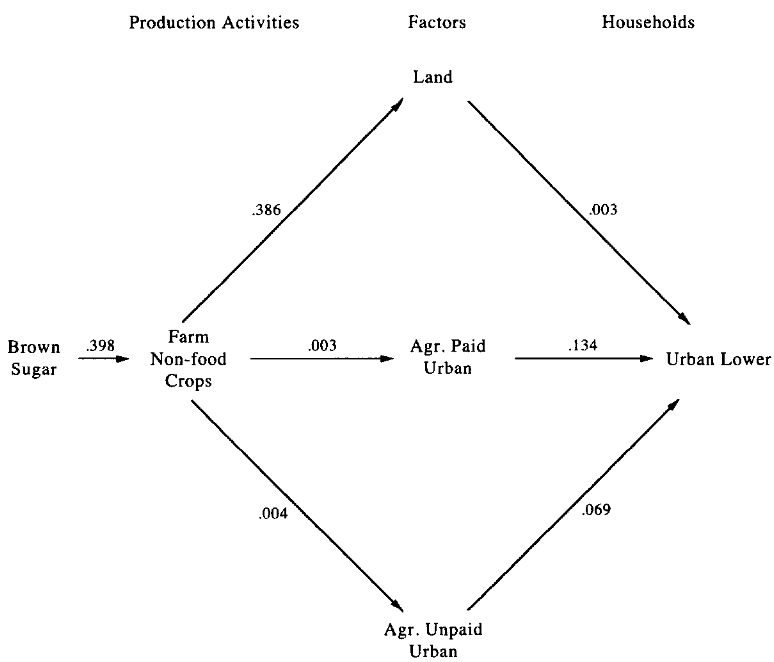

Figure 5. *Structural path network for the effects of brown sugar on the income of urban lower households.*

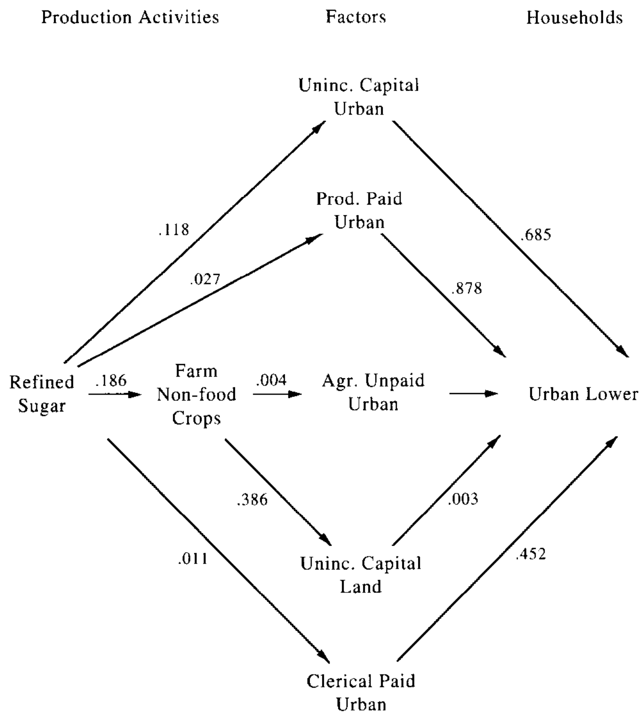

Figure 6. *Structural path network for the effects of refined sugar on the income of urban lower households.*

linkage from sugar (processing) to the group "unincorporated rural capital." In each case the magnitude of the linkage is considerably greater for brown than for white sugar. More specifically, whereas the path between brown sugar and nonfood crops has a marginal expenditure propensity of 0.398, the corresponding figure for white sugar is 0.186 and whereas the path from brown sugar to unincorporated rural capital has a marginal expenditure propensity of 0.346, the same path in the case of white sugar is associated with a marginal expenditure propensity of only 0.123.

Both these differences, we submit, are consistent with what one would expect on the basis of our previous analysis of technological systems. In particular, we suggested there that, for a number of reasons, backward linkage effects would tend to be more pronounced with traditional than modern techniques. Moreover, we suggested that modes of production in traditional technological systems are usually such that incomes are spread relatively widely among a large number of small-scale rural producers (who, in terms of SAM-TECH are represented as the owners of "unincorporated rural capital").

The third path diagram, dealing with "urban lower households," differs from the two previous paths in that it is the nature rather than the extent of the linkages that differs between the traditional and modern technologies. Thus, whereas there are three separate paths from refined sugar processing to urban factors of production (and ultimately to "urban lower households"), no such paths are apparent in the case of brown sugar. This rather striking result should be interpreted in conjunction with and is indeed the mirror image of, the paths linking brown sugar to rural factors of production in Figure 3.

For, whereas in that case brown sugar exhibited stronger and more numerous linkages to rural factors of production, in the urban context it is (only) refined sugar that exhibits the linkages to factors of production. In short, traditional technologies seem to belong to technological systems that are predominantly rural, whereas modern technologies appear to form part of technological systems that are primarily urban in character.

5. CONCLUSIONS

Of the many topics that fall under the heading nonagricultural technology and development, the connection between technology choice and income distribution has been treated perhaps the least satisfactorily. The main problem is that this relationship needs to be explored not only, as now, at the microeconomic level, but also at the level of the economy as a whole.

Progression to the latter took the form in our analysis, firstly, of identifying the mechanisms through which technology exerts an influence on the distribution of income at this level. For each of the mechanisms thus identified, we suggested that there are historical reasons why labor-intensive techniques tend to be more egalitarian in their impact than capital-intensive techniques. We were able to test these hypotheses by means of a disaggregated social accounting matrix (SAM) for Indonesia and we found structural path analysis of the SAM to be an especially useful tool for exploring the macroeconomic relationships in question. For the most part our empirical results confirm what the theoretical analysis led us to expect.

NOTES

1. The concept of a technological system is used in James and Khan (1993) to examine the employment effect of an income redistribution in favor of the poor.

2. Stewart (1977), p. 7.

3. Stewart (1977), p. 6.

4. Stewart (1977), p. 7.

5. The following discussion is taken from Khan (1989).

6. See Khan and Thorbecke (1988) for details.

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