The Use of Social Accounting Matrices in Modeling

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Revised Version

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1. INTRODUCTION

The SAM is a comprehensive, disaggregated, consistent and complete data system that captures the interdependence that exists within a socioeconomic system. Alternatively the SAM can be used as a conceptual framework to explore the impact of exogenous changes in such variables as exports, certain categories of government expenditures, and investment on the whole interdependent socioeconomic system, e.g. the resulting structure of production, factorial and household income distributions. As such the SAM becomes the basis for simple multiplier analysis and the building and calibration of a variety of applied general equilibrium models. The chosen taxonomy and the level of disaggregation depend critically on the questions that the SAM methodologies are expected to answer. If the SAM is to be used to explore issues related to income distribution then the household account is to be broken down into a number of relatively homogeneous household groups reflecting the socioeconomic characteristics of the country or region under consideration. On the other hand, if the purpose of the SAM is to analyze intersectoral linkages, then a relatively detailed sectoral disaggregation of production activities using such criteria as characteristics of the good or service produced and type of technology employed in production is called for.

This paper consists of four sections in addition to the introduction. Section 2 describes and analyzes the SAM in its dual roles as an accounting framework and as a conceptual framework for modeling. The major transformations inherent in a SAM, i.e. the triangular interactions linking production activities to factor incomes to household income determination and back to production activities, are scrutinized in detail. In addition, Section 2 addresses issues related to the appropriate criteria in the selection of the SAM taxonomy (classification scheme) and the data required in the construction of a SAM.

Section 3 is devoted to SAM multiplier analysis. The Keynesian assumptions required to validate the SAM multiplier analysis are reviewed in 3.1 and a prototypical example of a SAM of an Archetype African economy is presented in 3.2 and the corresponding multipliers derived. In 3.3, the concept of structural path analysis is introduced followed by a review of specific applications of SAM multiplier analysis in different settings to explore a variety of different issues at the national, regional and village levels, respectively.

Section 4.1 analyzes the structure and main features of general equilibrium models and shows how these models are built on the basis of a benchmark SAM. In particular, Computable General Equilibrium (CGE) models take their initial conditions and their taxonomies from their respective SAMs. The process through which CGEs are calibrated on the basis of SAMs is discussed. In 4.2 a brief and selective review of applied general equilibrium models is undertaken with special emphasis to applications in the Third World.

Finally, Section 5 concludes.

2. THE SAM AS AN ACCOUNTING SYSTEM AND AS A CONCEPTUAL FRAMEWORK

The genesis of the Social Accounting Matrix (SAM) goes back to Richard Stone's pioneering work on social accounts. Subsequently Graham Pyatt and Erik Thorbecke (1976) further formalized the SAM and showed how it could be used as a conceptual and modular framework for policy and planning purposes.[1]

As a data framework, the SAM is a comprehensive and disaggregated snapshot of the socioeconomic system during a given year. It provides a classification and

[1]This section of this paper draws on Pyatt and Thorbecke (1976), Thorbecke (1995), and Thorbecke (1998).

organizational scheme for the data useful to analysts and policymakers alike. It incorporates explicitly various crucial relationships among variables such as the mapping of the factorial income distribution from the structure of production and the mapping of the household income distribution from the factorial income distribution. Table 1 presents a basic SAM. It can readily be seen that it incorporates all major transactions within a socioeconomic system. Whereas the SAM in Table 1 is a snapshot of the economy, Figure 1 which reproduces all of the transformations appearing in Table 1, can be interpreted more broadly as representing flows (over time) which, in turn, have to be explained by structural or behavioral relationships.

Table 1 presents all the above flows in a basic SAM. A SAM is a square matrix in which each transactor or account has its own row and column. The payments (expenditures) are listed in columns and the receipts are recorded in rows. As the sum of all expenditures by a given account (or subaccount) must equal the total sum of receipts or income for the corresponding account, row sums must equal the column sums of the corresponding account. For example, the total income of a given institution (say a specific socioeconomic household group) must equal exactly the total expenditures of that same institution. This is the economic analog of the physicists' law of conservation of energy. Hence, analysts interested in understanding how the structure of production influences the income distribution can obtain useful insights by studying the SAM.

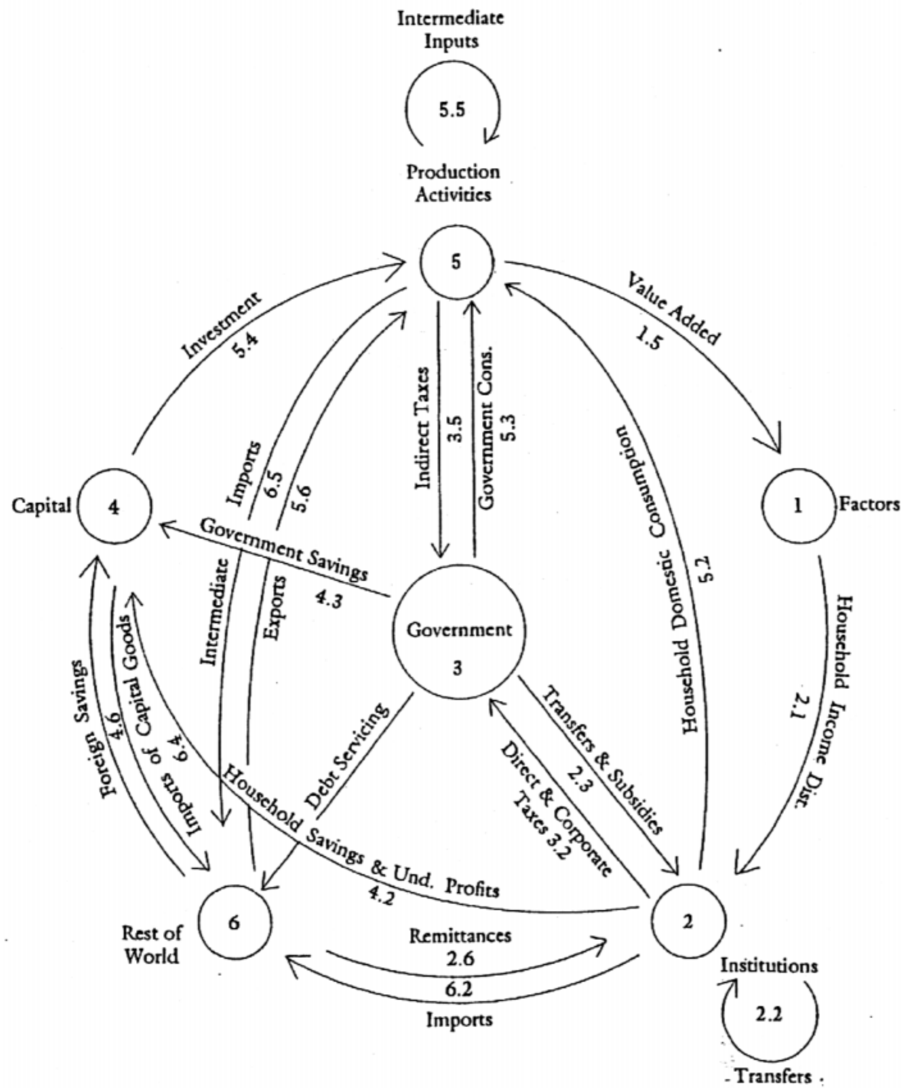
In the basic SAM of Table 1, six accounts are distinguished. Production activities produce different sectoral goods and services (e.g. textile products) by buying raw materials and intermediate goods and services. In addition these accounts pay indirect taxes to the government and the remainder is, by definition, value added that is distributed to the factors of production (see column 5). Production activities receipts (row 5) derive from sales to households, exports and the government. In the present formulation of the SAM no distinction is made between production activities and commodities. For the sake of simplicity, it is assumed that a production activity is

Table 1
A basic social accounting matrix (SAM)

		Expenditures: 1 Factors of production	2a Institutions – Current accounts – Households	2b Institutions – Current accounts – Companies	3 Institutions – Current accounts – Government	4 Institutions – Combined capital account	5 Production activities	6 Rest of the world combined account	Totals
Receipts: 1	Factors of production						Value added payments to factors	Net factor income received from abroad	Incomes of the domestic factors of production
2a	Institutions – Current accounts – Households	Allocation of labour income to household	Current transfers between households	Profits distributed to domestic households	Current transfers to domestic households			Net non-factor incomes received from abroad	Incomes of the domestic institutions after transfers
2b	Institutions – Current accounts – Companies	Allocation of operating surplus to companies			Current transfers to domestic companies				
3	Institutions – Current accounts – Government		Direct taxes on income and indirect taxes on current expenditures	Direct taxes on companies plus operating surplus of state enterprises		Indirect taxes on capital goods	Indirect taxes on inputs	Net non-factor incomes received plus indirect taxes on exports	
4	Institutions – Combined capital account		Household savings	Undistributed profits after tax	Gov't current account surplus			Net capital rec'd from abroad	Aggregate savings
5	Production activities		Household consumption expend. on dom. goods		Government current expenditure	Investment expenditures on domestic goods	Raw material purchases of domestic goods	Exports	Aggregate demand — gross outputs
6	Rest of the world combined account		Household consumption expend. on imp. goods			Imports of capital goods	Imports of raw materials		Imports
	Totals	Incomes of the domestic factors of production	Total outlay of households	Total outlay of companies	Total outlay of government	Aggregate Investment	Total costs	Total foreign exchange receipts	

Source: Thorbecke (1988)

Figure 1
Flow Diagram of SAM Transactions



[1]The flow diagram reflects exactly the transactions and transformations appearing in the SAM on Table 1. Note that transactions are numbered in a way consistent with the numbering of the Accounts in Table 1. For example, the allocation of value added is a receipt for the Factor Account (#1) and a payment by the Production Activities Account (#5); hence, the corresponding transformation (matrix) is denoted by 1.5.

Source: Thorbecke (1988)

equivalent to a corresponding commodity. In some instances, the SAM format distinguishes between production activities and commodity accounts. This would be the case when a given production activity produced different commodities, for example, so that these two sets of accounts would require different sectoral breakdowns. For this reason, many SAMs include both production activities and commodities accounts. When commodity accounts appear in a SAM they can best be seen as representing a region's or nation's product markets. Thus the SAM of an archetype African economy that is presented subsequently includes both a production and commodity accounts.

Factors of production accounts typically include labor and capital subaccounts. They receive income (recorded in row 1) from the sale of their services to production activities in the form of wages, rent and net factor income received from abroad or from other regions (corresponding to the value added generated by the production activities). In turn, these revenues are distributed (col. 1) to households as labor incomes and to companies as distributed profits.

Institutions include households (typically further broken down by socioeconomic groups), companies (i.e. firms) and the government. From row 2a, it can be seen that households receive factor income (wages and other labor income, rent, interest and profits) as well as transfers from government and from the rest of the nation and world (e.g. remittances). Households' expenditures (in column 2a) consist of consumption on goods from the region, from other regions and from abroad, and income taxes with residual savings transferred to the capital account. Companies (2b) receive profits and transfers and spend on taxes and transfers with their residual savings channeled into their capital account.

The government account (3) is distinct from administrative public activities included in the production activities' account. These public services (such as education) buy intermediate goods, pay wages and deliver public and administrative services. The government account per se allocates its current expenditures on buying the services provided by the production activities account. Other government expenditures (col. 3) are transfers and subsidies to households and companies and the remaining savings are transferred to the capital account. On the income side, the government receives tax revenues from a variety of sources and current transfers from abroad (row 3).

The fifth account is the combined capital account. On the income side (row 4) it collects savings from households, companies, the government as well as foreign savings and, in turn, channels these aggregate savings into investment (col. 4).

Finally, transactions between domestic residents, and foreign residents, respectively, are recorded in the rest of the world accounts (6). These transactions include, on the receipt side, households' consumption expenditures on imported final goods as well as imports of capital goods and raw materials (row 6). The economy receives income from the rest of the nation and world (col. 6) from exports and factor and nonfactor income earned. The difference between total foreign exchange receipts and imports is by definition net capital received from abroad or the rest of the nation and extraregional and foreign savings.

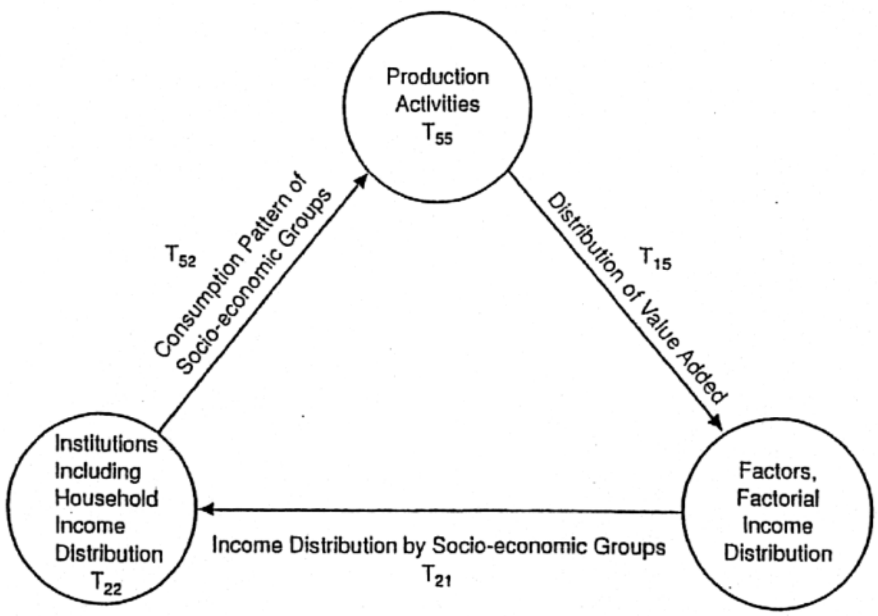
The SAM framework can also be used as a conceptual framework and as a basis for modeling. In this case the generating mechanisms influencing the flows appearing in Figure 1 have to be spelled out explicitly and quantitatively. Whereas the SAM in Table 1 is a snapshot of the economy, Figure 1 which reproduces all of the transformations appearing in Table 1, can be interpreted more broadly as representing flows (over a period of one year) which, in turn, have to be explained by structural or behavioral relationships.

The first question to address in a SAM-based framework is which accounts should be considered exogenous and which endogenous. It has been customary to consider the government, the rest of the world and the capital account as exogenous and the factors, institutions, and production activities' accounts as endogenous. To illustrate how the SAM approach lends itself to deriving the ultimate income distribution and expenditure pattern by socioeconomic groups following, say, a change in the structure of production resulting from government actions or a change in exports, distinguishing between the determination of primary and secondary income distribution is useful. Thus, a distinction is drawn between primary claims on resources which arise directly out of the productive process of work and accumulation, and secondary claims that result from the transfer of primary claims. The former results from prevailing patterns of 1) production and 2) resource endowment (human capital, physical capital and land) among households.

The primary income distribution is determined through the triangular interrelationship linking production activities, factors and households. In Figure 1 this interrelationship appears as the value added flow (denoted by arrow 1.5) from production activities to factor incomes; from the latter to household income determination and distribution (2.1) which yields, ultimately, the household domestic consumption pattern (5.2). While the primary income distribution is by far the most important determinant of incomes received by the various socioeconomic groups, a secondary income distribution may work through the family, village, or, more important, through the state in the form of transfers and subsidies (2.3) and taxes (3.2). Figure 2 reproduces this same key triangular interrelationship among production activities, the factorial income distribution and the household income distribution that is emphasized throughout this paper. In Section 3.1 the fundamental contribution of Pyatt and Round (1979) in formalizing the SAM multiplier decomposition, following the triangular channels of Figure 2, is discussed in detail.

If we are to understand and explain, in an operational way, the mechanisms through which these transformations occur, great care must be exercised in designing appropriate classification schemes for each of the three endogenous accounts. These transformations incorporate the mechanisms that translate the generation of value added by production into the incomes of different types of households and other institutions. The link is provided by factors of production. The level and structure of output by the different activities generate the aggregate demand for labor of different types, natural resources and capital services. Hence, employment enters into the analysis. The stream of value added, from the production side, rewards the factors of production, with wages

Figure 2 **Simplified relationship among Principal SAM accounts (Productive activities, Factors and institutions)[a]**



Source: Thorbecke (1992)

going to different types of labor, rent going to land and other resources, and profits to capital. In this way a picture is obtained of the factorial distribution of income which is captured in Table 1 by the interface between column 5 and row 1 and, analogously, by matrix T_{15} in Figure 2. With regard to production activities, four criteria suggest themselves in deriving an appropriate classification: 1) the nature of the item produced be it a good, service or commodity; 2) the type of technology used, in terms of labor and capital intensity, 3) the form of organization underlying the production process (i.e. farm or firm relying on family labor and self employment, as opposed to an incorporated, or even a state enterprise); and, 4) whether the commodities are tradable or nontradable.

In turn, the classification of factors and households should be consistent with our interest in employment and equity issues as poverty is endemic in the Third World. With the qualification that any ultimate taxonomy should be country specific, the following breakdown of factors may be suggested: 1) family labor (further broken down between unpaid and paid and self-employed and hired, and, if possible, distinguishing, as well, between male and female labor); 2) unskilled labor (with some of the same additional distinctions as in the above category; 3) skilled labor; and, 4) capital (which could be land or other forms of capital).

Translation from factorial distribution to the distribution of incomes across institutions, and particularly across different household groups, depends on which institutions own which factors. Thus, for example, wage payments to unskilled labor go to the households that provide semi-skilled labor; imputed labor income is received by small farmers from the services performed by self-employed family labor on their own farms, while rent income (whether imputed or not) accrues to the owners of land and other natural resources, and finally, profits accrue to owners of capital. This second transformation is shown in Table 1 by the interface between column 1 and row 2, as well as by matrix T_{21} in Figure 2. Three main criteria appear important in classifying households: a) location; b) resource endowment and wealth; and c) occupation of the head of the household. Location, particularly between rural and urban areas, is a crucial criterion largely on the grounds that policy often has a locational element and often an urban bias. Resource endowment is important at several levels. Access to land is a critical consideration in rural areas and the landless can be affected quite differently from the smallholder, or large farmers, by development policy. Likewise, the better educated in both the urban and rural areas are able to land jobs in formal and organized activities, whereas the uneducated are limited to employment opportunities largely in traditional agriculture and informal urban activities. The endowment of land and human capital is a crucial determinant of the ultimate income distribution and standards of living of the various socioeconomic household groups.

A third transformation in Figure 2 yields the consumption pattern of the different socioeconomic groups (interface between column 2a and row 5 in Table 1 and matrix T_{52} in Figure 2). It reveals the value of the commodities (assumed here to be equivalent to production activities) consumed by these groups. This transformation provides crucial information on the living standards of the various groups. Two final endogenous transformations appear in Figure 2 reflecting transfers occurring within, respectively, the production activities' account and the institutions account. T_{55} represents the matrix of intermediate demand by production activities and is nothing else than the conventional Input/Output table. T_{22} captures transfers among institutions and, in particular, transfers from some relatively better off socioeconomic groups to other poorer groups.

At this stage, one qualification needs to be made. Whereas the SAM approach explains the determination of total incomes accruing to the various socioeconomic groups, it does not generate the intra-group income distributions. To the extent that poverty tends to be concentrated in a few groups, such as the landless and small farmers in rural areas and the informal sector workers in urban areas, between-group variance is likely to explain a reasonably high proportion of total income variance in society. If one wants to approximate more exactly the impact on poverty of measures affecting the structure of production, knowledge of the income distributions within socioeconomic groups is necessary because poor households (those with incomes below a given normative poverty line) are likely to be found even in socioeconomic groups enjoying average income levels significantly higher than the poverty line. In Section 4.2 an example of a CGE built to explore the effects of trade shocks on poverty is discussed.

Classification matters in a fundamental sense whether the SAM is used as a diagnostic tool to understand better the underlying interdependent socioeconomic structure of an economy, or as a conceptual framework and basis for modelling. Economic concepts and variables must be represented in a SAM by appropriately corresponding classes and categories. To each conceptual framework, there must be a corresponding taxonomic and data system.

What are some of the key issues in deciding on a SAM classification scheme? First, the level and extent of disaggregation deserve consideration. In many instances given the policy issues a SAM is supposed to address, fairly aggregative SAMs broken down in relatively few categories will do. However, since it is always possible to consolidate and aggregate subaccounts—but not the other way around--it may be better to start at a level of disaggregation which is as detailed as data reliability allows. Secondly, the degree of homogeneity is crucial in the design of classifications. For example, in a classification of household groups, one would like to identify groups that are relatively homogeneous in terms of income sources and levels and expenditure patterns.

It has been argued that every classification should meet certain requirements if it is to be used in a SAM. A SAM taxonomy should a) correctly reproduce the socioeconomic and structural (production) stratification within the society and economy; b) distinguish relatively homogeneous groups and categories; c) be composed of socioeconomic groups that are recognizable for policy purposes and useful for socioeconomic analysis (i.e. specific target groups should be identified); d) be based on comparatively stable characteristics that can be measured relatively easily and reliably;

and e) be derivable from (a combination of) existing data sources (Alarcon Rivero et al., 1986).

There is no unique (standard) classification scheme or way of disaggregating and organizing the data in a SAM. The taxonomy used in any given SAM depends on the prevailing country or region specific characteristics and the objectives of the studies underlying the building of the SAM. In a SAM that emphasizes intersectoral linkages, the level of disaggregation of production activities needed to capture the structure of production is likely to be much smaller in poor developing countries than in an industrialized one. A SAM that is supposed to be used as a basis for exploring income distribution issues needs a finer disaggregation of socioeconomic household groups than one not highlighting income distribution.

A great strength of the SAM is that it explicitly breaks down households into relatively homogeneous socioeconomic categories that are recognizable for policy purposes and exhibit relatively stable characteristics. This type of disaggregation allows the SAM to be used to analyze the effects of government policies on income distribution. Recently the community of statisticians designed and recommended the adoption of a hierarchical classification of households which shows a top down tree structure at different levels. (For an interesting discussion of the importance of an appropriate households taxonomy, see Duchin, 1996.)

A final key issue that goes to the heart of defining and deciding on the domain of the SAM and that transcends across accounts is that of regionalization.[2] While most SAM studies have been undertaken with national objectives in mind, yet it has been realized that distinguishing regions within a country SAM can enhance both its realism and its usefulness. If the economy displays significant regional differences in the types of goods produced, structure of production and technology, these differences could affect the

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[2] This subsection on regionalization draws on Thorbecke (1985).

standards of living of different household groups. Another important advantage of the explicit inclusion of the regional dimension into a SAM conceptual framework is that a large number of policy means tend to be location-specific. These may include investment projects, current government expenditures on services, such as health and education, and price policies with respect to commodities and inputs at least to the extent that the production of specific commodities is regionally concentrated.

A variety of data sources are required to build a SAM. Because the methods used in collecting and generating statistics differ significantly from one source to another (such as national income accounts, input-output, census information, surveys, etc.) the process of building a SAM provides a natural check on the mutual consistency of these sources and identifies possible data gaps and errors. In this sense the process of reconciliation that is endemic in generating a SAM has social value in its own right.[3] There are different techniques for reconciling and forcing consistency within a SAM that does not balance-- the most naïve and mechanical one being the RAS technique. Generally, it is far preferable to use judgments than mechanical approaches in insuring that a SAM is consistent and balanced.

Given the degree of country or regional specificity and the numerous different objectives which construction of the SAM may have, it is not possible to identify a unique and general set of required data. The more disaggregated a SAM is intended to be, the more extensive are the data requirements. Some scholars maintain that 'In all cases, the starting point should be the building of a highly aggregated SAM based on the country's national accounts statistics.' (Sadoulet and de Janvry, 1995, p. 280) Others

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[3] In this connection, it is relevant to note that when a team of resident experts attached to the CBS in Jakarta was trying to build the first SAM for Indonesia in the late 70s, the local Indonesian statisticians only became interested in, and supportive of this exercise when they realized that the SAM provided an ideal framework within which to check data consistency and help reconcile inconsistencies. Soon thereafter the process of building SAMs was institutionalized within the CBS and so far at least six large-scale, highly disaggregated SAMs have been prepared and published by the CBS (for 1975, 1980, 1985, 1990, 1995, and 1999, respectively).

would contend that a more accurate and sensible approach for regional and interregional analyses and even national is to construct a SAM region by region with interregional flows increasingly disaggregated.

There is no optimal sequence in which to proceed with the construction of a SAM. A good starting point is with the production activities' account since the SAM can be seen as a major expansion on, and extension of an I-O matrix. A second step might consist of breaking down value added (matrix $\mathbf{T_{15}}$ in Table 1) into income accruing to different labor categories and profits and rent going to one or more capital categories with the help of employment surveys and agricultural and industrial synthesis.

A third step could yield the incomes of the various socioeconomic groups relying on household income and expenditure surveys. Particularly crucial, in this context, is the mapping of the household income distribution from the factorial income distribution ($\mathbf{T_{21}}$). On the household expenditure side, again consumption surveys together with information on taxes available from the government budget should provide the main spring for filling out column 2a of Table 1. Finally, a detailed balance of payments supplemented by disaggregated trade statistics should make it possible to record transactions with the rest of the world.

A final data and formatting issue is that the great majority of the existing SAMs contain only a rudimentary breakdown of financial transactions. When one of the objectives of the SAM is to highlight the flow of funds among various financial institutions, households and firms and the portfolios of different financial assets of these institutions, a financial SAM needs to be built.

3. SAM MULTIPLIER ANALYSIS

3.1 The Derivation of SAM Multipliers

If a certain number of conditions are met—in particular, the existence of excess capacity and unemployed or underemployed labor resources—the SAM framework can be used to estimate the effects of exogenous changes and injections, such as an increase in the demand for a given production activity, government expenditures or exports on the whole system. As long as excess capacity and a labor slack prevail, any exogenous change in demand can be satisfied through a corresponding increase in output without having any effect on prices. Thus, for any given injection anywhere in the SAM, influence is transmitted through the interdependent SAM system. The total, direct and indirect, effects of the injection on the endogenous accounts, i.e. the total outputs of the different production activities and the incomes of the various factors and socioeconomic groups are estimated through the multiplier process. For example, a public works program resulting in the construction of a new rural farm to market road would require, among others, a significant amount of unskilled labor that is typically provided by the landless and small farmers' household categories. In turn, a significant part of the incremental incomes earned by these two socioeconomic groups from their work on the road project is spent on food demand. The subsequent increase in food production to satisfy that demand leads to still further employment and income increments for these groups, and so on, until the multiplier process dampens.

To derive and illustrate the underlying logic of this methodology, let us at the outset assume, following the previous discussion that the only three accounts which are endogenously determined are production activities, factors, and institutions (households and companies), while all other accounts are exogenous (government, capital, and the rest of the world). The resulting simplified SAM is presented in Table 2. Thus the above simplified and truncated SAM consolidates all exogenous transactions and corresponding

Table 2 Simplified Schematic Social Accounting Matrix

				Expenditures				
				Endogenous Accounts			Exog.	
					Institutions			
				Factors	Households and Companies	Production Activities	Sum of Other Accounts	Totals
				1	2	3	4	5
Receipts	Endogenous Accounts	Factors	1	0	0	T_{13}	x_1	y_1
		Institutions, i.e. Households and Companies	2	T_{21}	T_{22}	0	x_2	y_2
		Production Activities	3	0	T_{32}	T_{33}	x_3	y_3
	Exog	Sum of Other Accounts	4	l'_1	l'_2	l'_3	t	y_x
		Totals	5	y'_1	y'_2	y'_3	y_x	

Source: Thorbecke (1995)

leakages and focuses exclusively on the endogenous transactions and transformations. Five endogenous transformations appear in Table 2. Note that the three exogenous accounts have been combined together in Table 2 and the sum of the exogenous injections from government expenditures, investment and exports, respectively, has been consolidated into three vectors $\mathbf{x}_1$, $\mathbf{x}_2$, and $\mathbf{x}_3$. The first vector ($\mathbf{x}_1$) represents the total exogenous demand for factors (and hence income injection to reward factors). Similarly $\mathbf{x}_2$ and $\mathbf{x}_3$ represent respectively the total exogenous income accruing to the different socioeconomic household groups and companies from, say, government subsidies, and remittances from abroad and the total exogenous demand for the production activities (commodities) resulting from government consumption, investment and export demand. Likewise l'_i represent the corresponding leakages, from savings, imports and taxation.

The logic underlying the scheme in Table 2, as will be seen shortly, is that exogenous changes (the x_i's) in Table 2 determine, through their interaction within the SAM matrix, the incomes of the endogenous accounts, i.e., i) the production activities (vector y_3); ii) the factor incomes (y_1); and iii) the household and companies incomes (y_2).

For analytical purposes, the endogenous part of the transaction matrix is converted into the corresponding matrix of average expenditure propensities or coefficients. These can be simply obtained by dividing a particular element in any of the endogenous accounts by the total income for the column account in which the element occurs. From Table 2 it can be seen that A_n is partitioned as follows (i.e. A_n is composed of different subsets of coefficients)

$$\mathbf{A}_n = \begin{bmatrix} 0 & 0 & \mathbf{A}_{13} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & 0 \\ 0 & \mathbf{A}_{32} & \mathbf{A}_{33} \end{bmatrix} \qquad (1.1)$$

The subset $\mathbf{A}_{33}$ is the set of input output coefficients reflecting the cents worth of inputs per dollar of each production activity's output. The subset $\mathbf{A}_{13}$ is the set of cents worth of primary inputs per dollar of output of each production activity. The coefficients of the subset $\mathbf{A}_{32}$ show, on average, the cents worth of each commodity (production activity) that each (socioeconomic) household group purchases with each of its dollar of total expenditures. The coefficients of the subset $\mathbf{A}_{22}$ shows, on average, the cents worth of income transfers to other household groups per dollar of income. Finally, $\mathbf{A}_{21}$ shows the cents worth of each dollar earned by each type of resource (primary input) that is allocated to each of the household groups.

From the definition of $\mathbf{A}_n$, it follows that in the transaction matrix, each endogenous total income ($\mathbf{y}_n$) is given as

$$\mathbf{y}_n = \mathbf{A}_n \mathbf{y}_n + x \qquad (1.2)$$

which states that row sums of the endogenous accounts can be obtained by multiplying the average expenditure propensities for each row by the corresponding column sum and adding exogenous income x.

Equation (1.2) can be rewritten as

$$\begin{aligned} \mathbf{y}_n &= (I - A_n)^{-1} x \\ &= M_a x \qquad (1.3) \end{aligned}$$

Thus, from (1.3), endogenous incomes y_n (i.e. production activity incomes, y_3, factor incomes, y_1, and institution incomes, y_2 as shown in Table 2) can be derived by premultiplying injection x by a multiplier matrix M_a. This matrix has been referred to as the <u>accounting multiplier matrix</u> because it explains the results obtained in a SAM and not the process by which they are generated. The latter would require the specification of a dynamic model including the different SAM accounts and variables.

One limitation of the accounting multiplier matrix M_a. as derived in equation (1.3), is that it implies unitary expenditure elasticities (the prevailing average expenditure propensities in A_n are assumed to apply to any incremental injection). While this assumption may be defensible for all other elements of A_n, it is certainly unrealistic for the expenditure pattern of the household groups (A_{32}). 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. In this case, $\mathbf{C}_n$ formally differs from $\mathbf{A}_n$ in the following way: $\mathbf{C}_{13} = \mathbf{A}_{13}$, $\mathbf{C}_{33} = \mathbf{A}_{33}$, $\mathbf{C}_{22} = \mathbf{A}_{22}$, $\mathbf{C}_{21} = \mathbf{A}_{21}$, but $\mathbf{C}_{32} \neq \mathbf{A}_{32}$.

Expressing the changes in incomes ($d\mathbf{y}_n$) resulting from changes in injections ($d\mathbf{x}$), one obtains

$$d\mathbf{y}_n = \mathbf{C}_n d\mathbf{y}_n + d\mathbf{x} = (I - \mathbf{C}_n)^{-1} d\mathbf{x} = \mathbf{M}_c d\mathbf{x}. \quad (1.4)$$

$\mathbf{M}_c$ has been coined a <u>fixed price multiplier matrix</u> and its advantage is that it allows any nonnegative income and expenditure elasticities to be reflected in $\mathbf{M}_c$.

At this stage, it is important to spell out explicitly the multiplier mechanism which results from equation (1.3).[4] An understanding of this mechanism requires that the accounting (or fixed price) multipliers be decomposed following the triangular channels shown in Figure 2. Pyatt and Round (1979) made a seminal contribution to this decomposition, which is presented next. Equation (1.2) can be written out in explicit form as

$$\begin{aligned} y_1 &= && A_{13}y_3 + x_1 \\ y_2 &= A_{21}y_1 + A_{22}y_2 && + x_2 \\ y_3 &= A_{32}y_2 && + A_{33}y_3 + x_3 \end{aligned} \quad (1.5.a)$$

which yields

$$\begin{aligned} y_1 &= A_{13}y_3 + x_1 \\ y_2 &= (I - A_{22})^{-1}A_{21}y_1 + x_2 \\ y_3 &= (I-A_{33})^{-1}A_{32}y_2 + (I-A_{33})^{-1}x_3 \end{aligned} \quad (1.5.b)$$

This last set of relationships can be represented graphically (and superimposed on Figure 2) to yield Figure 2a, which shows clearly and explicitly the mechanisms through

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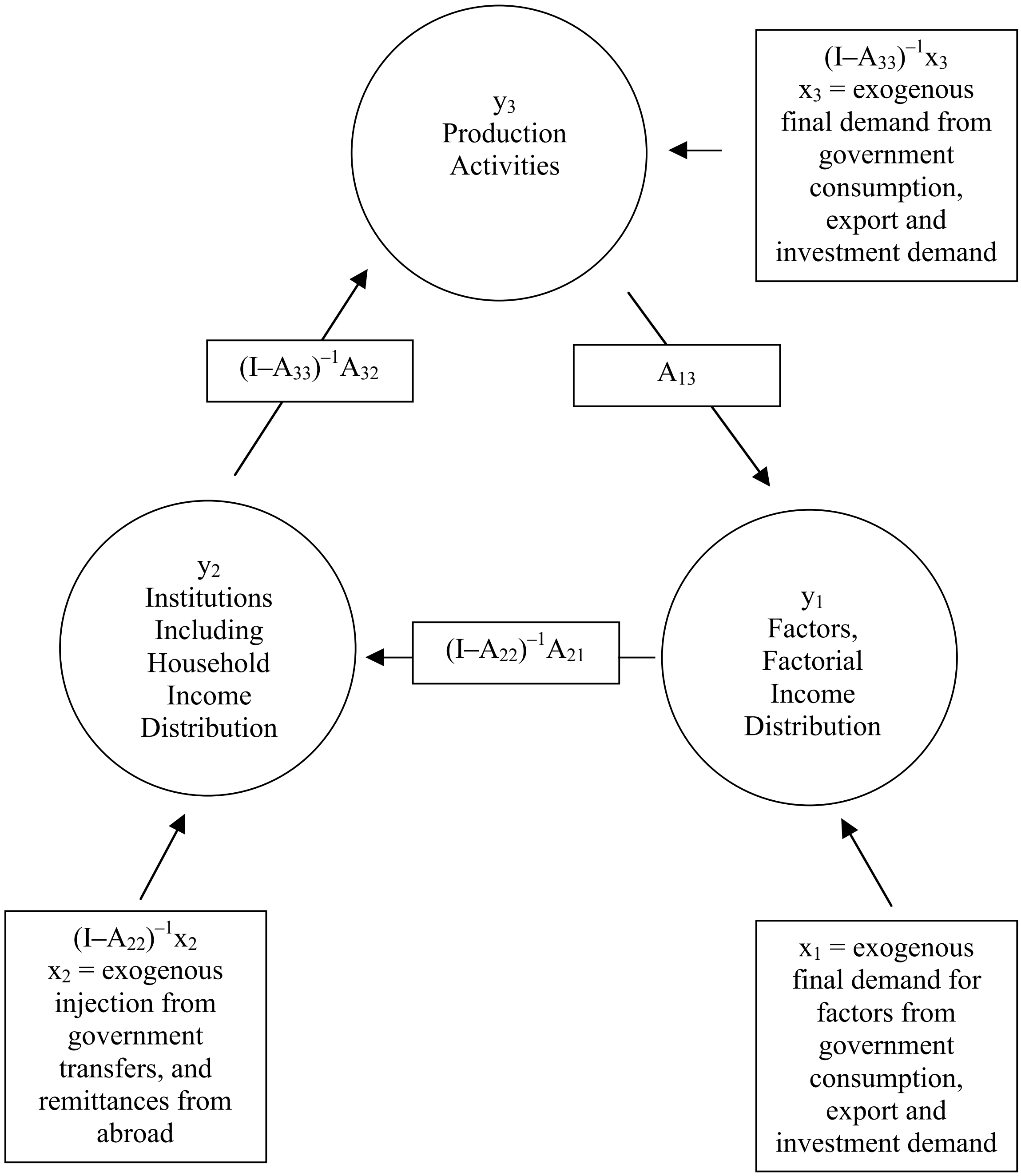
[4] The decomposition of the multiplier mechanisms that follows applies to the accounting multiplier $\mathbf{M}_a$. Exactly the same decomposition procedure can be used with respect to the fixed price multiplier $\mathbf{M}_c$.

Figure 2a. Multiplier Process among Endogenous SAM accounts*



*This diagram is an adaptation of Pyatt and Round (1979), Figure 1. The different mechanisms through which an exogenous injection affects the three endogenous accounts (incomes of factors, incomes of socioeconomic groups and outputs of production activities) are made explicit in this diagram. It is based on the decomposition appearing in equation (1.5.b).

which the multiplier process operates. Thus starting with an exogenous increase (injection) of export, government, or investment demand x_3, for example, this generates a rise in the output of the corresponding production activity of $(I–A_{33})^{-1}$ x_3. In turn, the additional factors of production which have to be employed to create the additional output generate a stream of value added $A_{13}y_3$ which constitutes factor income in addition to any exogenous factor income received from other regions or from abroad and from the government, namely x_2.

In the next link, households (and companies) receive income based on their resource endowment (A_{21}) and transfers system (A_{22}) as well as exogenous government subsidies and transfer payments and remittances from other regions and abroad, i.e. $(I–A_{22})^{-1}x_2$. Finally, the triangle is closed through the pattern of household (and companies) expenditures on commodities which translates into new production and a corresponding additional flow of income accruing to production activities equal to,

$$y_3 = (I–A_{33})^{-1}(A_{32}+x_3)$$

This formulation generalizes the Leontief model by including as one of the elements of final demand the effects of income distribution (y_2) on the consumption of the various socioeconomic groups (through A_{32}) which reflects the consumption pattern of each group of households. In contrast the open Leontief model with households in the final demand vector can be expressed as follows using the same notation

$$y_3 = (I–A_{33})^{-1}x_3 \tag{1.6}$$

where A_{33} is the input-output coefficient matrix and x_3 is exogenous total final demand. It is obvious that the SAM formulation (1.6) contains more information and a higher degree of endogeneity since it captures the endogenously derived effects of income distribution on consumption, which the Leontief national model does not.

3.2 A SAM and Multiplier Analysis of an Archetype African Economy

Table 3 presents an illustrative example of a SAM for an archetype African developing economy. Although it was calibrated to reflect approximately the socioeconomic structure of Côte d'Ivoire, it should be considered as a demonstration SAM reflecting many of the characteristics of a prototype African economy.[5] The SAM is disaggregated in terms of four factors, i.e. unskilled labor, skilled labor, capital and agricultural capital (i.e. land); six categories of households, i.e. rural (landless) workers, rural land owners (small), rural land owners (large), urban low education (and hence relatively low income), urban high education (high income)[6], and capitalists; and enterprises. Six production activities are identified i.e. domestic agriculture, export agriculture, mining, industries, services, and public services. Finally, five different commodities are specified i.e. domestic agriculture, export agriculture, mining, industries, and services.

Table 4 which is derived from Table 3 gives the matrix of average expenditure propensities (A_n) for this archetype African economy. A few examples suffice to show the type of information contained in Table 4. Thus, it can be seen that out of total domestic agricultural production unskilled labor receives 30%, capital 6% and agricultural capital 30% (column 12). In turn, total intermediate inputs used in agriculture amount to 32% (column 12). If one were interested in the consumption pattern of rural workers, one could determine from column 5 that 38% of their total income (equal expenditures) was spent on food commodities (agriculture), 34% on manufacturing goods and 23% on services. Rural workers households save nothing and pay only 5% in taxes.

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[5] This section draws on Decaluwe et al. (1999) and Thorbecke and Stifel (1998).

[6] For example, one could classify "low education" households as those in which the head of the household possessed the equivalent of a primary education or less; and "high education" households as those in which the head possessed more than a primary education.

Table 3: Social Accounting Matrix for Archetype African Developing Country

			Factors				Households							Activities						Commodities								
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
	Unskilled labour	1												365.5	81.0	38.5	474.2	293.2	267.8									1 520.2
Factors	Skilled labour	2												4.5	10.0	144.6	107.8	97.7	202.2									566.8
	Capital	3												72.0	30.0	292.4	955.3	567.1	11.9									1 928.7
	Land	4												361.6	85.0	0.0	0.0	0.0	0.0									446.6
	Rural workers	5	228.0	0.0	0.0	0.0																			20.0			248.0
	Rural land-owners (small)	6	790.5	0.0	255.9	156.3																			0.0			1 202.7
H'holds	Rural land-owners (large)	7	76.0	141.7	511.8	290.3																			0.0			1 019.8
	Urban low education	8	425.7	0.0	85.3	0.0																			20.0			531.0
	Urban high education	9	0.0	226.7	341.2	0.0																			0.0			567.9
	Capitalists	10	0.0	198.4	511.8	0.0																			0.0			710.2
	Entreprise	11			222.7																							
	Agriculture	12																		1 038.3		0.0	0.0	0.0			181.2	1 219.5
	Export Africulture	13																			50.0						231.0	281.0
Activities	Mining	14																		0.0		507.4	0.0	0.0			535.0	1 042.4
	Industries	15																		0.0		0.0	2 135.1	0.0			195.0	2 330.1
	Services	16																		0.0		0.0	0.0	1 325.0			110.0	1 435.0
	Public Services	17																		0.0		0.0	0.0	594.0			0.0	594.0
	Agriculture	18					95.0	412.7	271.9	171.6	97.1	32.4		204.8		0.0	323.3	0.0	0.0						0.0	274.9		1 883.7
	Exp. Agr.	19					0.0	0.0	0.0	0.0	0.0	0.0			40.0											10.0		50.0
Comm.	Mining	20					0.0	0.0	0.0	0.0	0.0	0.0		0.0		19.3	43.1	0.0	0.0						0.0	445.0		507.4
	Industries	21					83.1	402.8	384.2	191.7	242.4	153.1		186.1	30.0	337.5	301.7	143.3	0.0						0.0	50.0		2 505.9
	Services	22					57.5	291.0	271.9	141.2	146.1	98.6		0.0		173.6	43.1	247.6	76.5						471.9	0.0		2 019.0
	Government	23					12.4	60.1	51.0	26.5	28.4	71.0		25.0	5.0	36.5	81.6	86.1	35.6	85.6		0.0	74.2	0.0				679.0
	Accumulation	24					0.0	36.1	40.8	0.0	53.9	355.1	222.7												167.1		-95.8	779.9
	ROW	25																		759.8		0.0	296.6	100.0				1 156.4
	Total		1 520.2	566.8	1 928.7	446.6	248.0	1 202.7	1 019.8	531.0	567.9	710.2	222.7	1 219.5	281.0	1 042.4	2 330.1	1 435.0	594.0	1 883.7	50.0	507.4	2 505.9	2 019.0	679.0	779.9	1 156.4	

Source: Thorbecke and Stifel (1998)

Table 4: Matrix of Average Expenditure Propensities (An) for an Archetype African Developing Economy

			Factors				Households							Activities						Commodities							
			Unsk. L	Skilled L	Capital	Agr.Cap	R worker	R own. Sm	R own lg	Urb. Low	Urb. High	Capitalist	Enter	Agr.	Ex. Agr.	Mining	Indust.	Services	Pub. Serv.	Agr.	Ex. Agr.	Mining	Indust.	Services	Gov't	Accum.	ROW
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Unskilled labour	1												0.30	0.29	0.04	0.20	0.20	0.45								
Factors	Skilled labour	2												0.00	0.04	0.14	0.05	0.07	0.34								
	Capital	3												0.06	0.11	0.28	0.41	0.40	0.02								
	Agr. Capital	4												0.30	0.30	0.00	0.00	0.00	0.00								
	Rural workers	5	0.15	0.00	0.00	0.00																			0.03		
	Rural land-owners (small)	6	0.52	0.00	0.13	0.35																			0.00		
H'holds	Rural land-owners (large)	7	0.05	0.25	0.27	0.65																			0.00		
	Urban low education	8	0.28	0.00	0.04	0.00																			0.03		
	Urban high education	9	0.00	0.40	0.18	0.00																			0.00		
	Capitalists	10	0.00	0.35	0.27	0.00																			0.00		
	Entreprise	11	0.00	0.00	0.12	0.00																					
	Agriculture	12																		0.55	0.00	0.00	0.00	0.00			0.16
	Export Africulture	13																		0.00	1.00	0.00	0.00	0.00			0.20
Activities	Mining	14																		0.00	0.00	1.00	0.00	0.00			0.46
	Industries	15																		0.00	0.00	0.00	0.85	0.00			0.17
	Services	16																		0.00	0.00	0.00	0.00	0.66			0.10
	Public Services	17																		0.00	0.00	0.00	0.00	0.29			0.00
	Agriculture	18					0.38	0.34	0.27	0.32	0.17	0.05		0.17	0.00	0.00	0.14	0.00	0.00						0.00	0.35	
	Exp. Agr.	19					0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.14	0.00	0.00	0.00	0.00						0.00	0.01	
Comm.	Mining	20					0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.02	0.02	0.00	0.00						0.00	0.57	
	Industries	21					0.34	0.33	0.38	0.36	0.43	0.22		0.15	0.11	0.32	0.13	0.10	0.00						0.00	0.06	
	Services	22					0.23	0.24	0.27	0.27	0.26	0.14		0.00	0.00	0.17	0.02	0.17	0.13						0.69	0.00	
	Government	23					0.05	0.05	0.05	0.05	0.05	0.10		0.02	0.02	0.04	0.04	0.06	0.06	0.05	0.00	0.00	0.03	0.00			
	Accumulation	24					0.00	0.03	0.04	0.00	0.09	0.50	1.00												0.25		-0.08
	ROW	25																		0.40			0.12	0.05			

Finally Table 5 presents the matrix of accounting multipliers for this same archetype economy. The following example can illustrate how this multiplier table can be interpreted. As mentioned previously, the endogenous accounts are factors, households, activities and commodities while the government account, the capital account and the rest of the world are taken as exogenously determined. Thus, if one were interested in the impact of a change in agricultural exports on the whole socioeconomic system, one could read the corresponding multipliers along column 13 of Table 5. In this case **x** in equation (3) would reflect a change in agricultural exports and an assumed 100 units of reduction in exports would reduce the incomes of rural workers by 12 units, rural land owners (small) by 68 units, rural land owners (large) by 58 units, urban low education households by 26 units, urban high education households by 19 units and finally it would reduce the incomes of capitalists by 24 units, respectively (read down column 13 of Table 5). A perusal of Table 5 reveals that changes in different types of exports have very different distributional consequences as the intersection of the activities accounts (columns 12-17) and household income accounts (rows 5-10) shows.

A crucial feature of a SAM is that it provides disaggregated information on income distribution across socioeconomic household groups (the row total in Table 3) as well as the factorial sources of income of each household category (i.e. the transaction submatrix T_{21} or coefficient submatrix A_{21} in Table 2). As indicated previously this matrix reflects the resource (factor) endowment of the different household groups. The SAM also reveals the sectoral production origin of factorial income (T_{13} and A_{13}, respectively). This mapping reflects the structure of production and the technology used to produce the different production activities.

Table 6 presents the factorial source of income for each socioeconomic group in the archetype African economy.

Table 5: Accounting Multipliers for the Archetype African Developing Economy

			Factors				Households							Activities						Commodities				
			Unsk. L	Skilled L	Capital	Agr. Cap	R. worker	own sm	R own lg	Urb. Low	Urb. high	Captlst	Enter.	Agr.	Ex. Agr.	Mining	Indust.	Services	Ub. Services	Agr.	Ex. Agr.	Mining	Indust.	Services
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	Unskilled labor	1	1.5	0.4	0.37	0.5	0.5	0.49	0.5	0.51	0.48	0.23	0,00	0.77	0.81	0.51	0.62	0.65	0.91	0.43	0.81	0.51	0.53	0.69
Factors	Skilled labor	2	0.14	1.12	0.11	0.14	0.14	0.14	0.15	0.15	0.14	0.07	0,00	0.13	0.18	0.29	0.16	0.21	0.48	0.07	0.18	0.29	0.14	0.28
	Capitalists	3	0.57	0.48	1.43	0.57	0.56	0.56	0.58	0.59	0.58	0.29	0,00	0.6	0.69	0.88	0.9	0.92	0.55	0.33	0.69	0.88	0.77	0.77
	Agr. Capital	4	0.14	0.09	0.09	1.13	0.15	0.14	0.13	0.14	0.11	0.05	0,00	0.44	0.48	0.1	0.12	0.1	0.11	0.24	0.48	0.1	0.1	0.1
	Rural workers	5	0.23	0.06	0.05	0.07	1.08	0.07	0.07	0.08	0.07	0.03	0,00	0.12	0.12	0.08	0.09	0.1	0.14	0.06	0.12	0.08	0.08	0.1
	Rural lan-owners (small)	6	0.91	0.3	0.41	0.73	0.39	1.38	0.38	0.4	0.36	0.17	0,00	0.64	0.68	0.42	0.49	0.5	0.58	0.35	0.68	0.42	0.41	0.5
H'holds	Rural land-owners (large)	7	0.35	0.49	0.49	0.95	0.31	0.3	1.3	0.31	0.29	0.14	0,00	0.52	0.58	0.39	0.39	0.39	0.38	0.28	0.58	0.39	0.33	0.37
	Urban Low Education	8	0.45	0.13	0.17	0.16	0.17	0.16	0.17	1.17	0.16	0.08	0,00	0.24	0.26	0.18	0.21	0.22	0.28	0.13	0.26	0.18	0.18	0.23
	Urban High Education	9	0.16	0.53	0.3	0.16	0.15	0.15	0.16	0.16	1.16	0.08	0,00	0.16	0.19	0.27	0.22	0.25	0.29	0.09	0.19	0.27	0.19	0.25
	Capitalists	10	0.2	0.52	0.42	0.2	0.2	0.2	0.21	0.21	0.2	1.1	0,00	0.2	0.24	0.33	0.3	0.32	0.31	0.11	0.24	0.33	0.25	0.3
	Enterprise	11	0.07	0.06	0.17	0.07	0.06	0.06	0.07	0.07	0.07	0.03	1,00	0.07	0.08	0.1	0.1	0.11	0.06	0.04	0.08	0.1	0.09	0.09
	Agriculture	12	0.48	0.31	0.31	0.45	0.51	0.48	0.44	0.48	0.37	0.16	0,00	1.49	0.42	0.32	0.41	0.33	0.37	0.82	0.42	0.32	0.35	0.33
Activities	Export Agriculture	13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1.17	0,00	0,00	0,00	0,00	0,00	1.17	0,00	0,00	0,00
	Mining	14	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0,00	0.02	0.02	1.04	0.03	0.01	0.01	0.01	0.02	1.04	0.03	0.01
	Industries	15	0.87	0.75	0.67	0.88	0.86	0.85	0.89	0.9	0.92	0.45	0,00	0.88	0.9	0.95	1.78	0.77	0.75	0.48	0.9	0.95	1.52	0.73
	Services	16	0.44	0.37	0.34	0.45	0.43	0.43	0.46	0.46	0.44	0.22	0,00	0.36	0.4	0.45	0.34	1.47	0.47	0.2	0.4	0.45	0.29	1.1
	Public Services	17	0.2	0.17	0.15	0.2	0.19	0.19	0.2	0.21	0.2	0.1	0,00	0.16	0.18	0.2	0.15	0.21	1.21	0.09	0.18	0.2	0.13	0.49
	Agriculture	18	0.87	0.57	0.56	0.82	0.92	0.87	0.79	0.87	0.68	0.29	0,00	0.89	0.75	0.58	0.74	0.6	0.68	1.49	0.75	0.58	0.63	0.6
	Export Agriculture	19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0.17	0,00	0,00	0,00	0,00	0,00	1.17	0,00	0,00	0,00
Comm.	Mining	20	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0,00	0.02	0.02	0.04	0.03	0.01	0.01	0.01	0.02	1.04	0.03	0.01
	Industries	21	1.02	0.88	0.79	1.03	1.01	1,00	1.05	1.05	1.08	0.53	0,00	1.03	1.06	1.12	0.92	0.9	0.88	0.57	1.06	1.12	1.78	0.85
	Services	22	0.67	0.56	0.51	0.68	0.65	0.66	0.69	0.7	0.67	0.34	0,00	0.55	0.61	0.68	0.52	0.71	0.72	0.31	0.61	0.68	0.44	1.68
	Total Factors		2.35	2.09	2,00	2.35	1.35	1.33	1.36	1.39	1.31	0.64	0,00	1.94	2.15	1.78	1.81	1.88	2.05	1.07	2.15	1.78	1.54	1.84
	Total Labor		1.64	1.52	0.47	0.64	0.64	0.63	0.64	0.66	0.62	0.3	0,00	0.9	0.98	0.8	0.79	0.86	1.39	0.5	0.98	0.8	0.67	0.97
	Total Institutions		2.35	2.09	2,00	2.35	2.35	2.33	2.36	2.39	2.31	1.64	1,00	1.94	2.15	1.78	1.81	1.88	2.05	1.07	2.15	1.78	1.54	1.84
	Total Activities		2,00	1.61	1.48	2,00	2.01	1.97	2.01	2.06	1.95	0.94	0,00	2.91	3.08	2.96	2.71	2.79	2.82	1.6	3.08	2.96	2.31	2.66
	Total Commodities		2.58	2.02	1.87	2.55	2.6	2.54	2.56	2.64	2.44	1.17	0,00	2.48	2.61	2.42	2.21	2.23	2.29	2.37	3.61	3.42	2.88	3.14

Table 6: Factorial Source of Household Income (matrix A_{21} in Table 2)

	Unskilled Labor	Skilled Labor	Capital	Land	Transfers	Total
Rural Workers	91.94%				8.06%	100%
Small Rural Landowners	65.72%		21.28%	13.00%		100%
Large Rural Landowners	7.45%	13.89%	50.19%	28.47%		100%
Urban Low education	80.17%		16.06%		3.77%	100%
Urban High education		39.92%	60.08%			100%
Capitalists		27.94%	72.06%			100%

As we can observe in Table 6, the composition of income of each household group is related to its social classification. The incomes of the rural workers, the small rural landowners and urban low education consist mostly of unskilled labor receipts, while large landowners, the urban high education and the capitalist households receive the bulk of their income from capital and land rent.

In Table 7, we present the share of the primary factors in the value-added for each branch of production. The agricultural (traditional and export agriculture) and services (service and public service) sectors are mostly intensive in unskilled labor and the industrial (mining and industries) sectors intensive in the capital primary factor. Skilled labor is used more intensively in the public services branch and in the mining branch. As for land, only the agricultural branches share this resource.

Table 7: Share of the Primary Factors in the Value-Added

	Agriculture	Export Agriculture	Mining	Industries	Services	Public Service
Unskilled Labor	45.48%	39.32%	8.1%	30.85%	30.61%	55.57%
Skilled Labor	0.56%	4.85%	30.41%	7.01%	10.2%	41.96%
Capital	8.96%	14.56%	61.49%	62.14%	59.2%	2.47%
Land	45.00%	41.26%				
Total	100%	100%	100%	100%	100%	100%

It will be seen in the next section where a CGE is calibrated on the present archetype African SAM and used to simulate, among others, a trade shock that the latter affects income distribution through its impact on factor employment. In summary the impact of exogenous shocks are transmitted throughout the channels of the socioeconomic system given by archetype SAM. By studying Tables 6 and 7, we can see that a shock affecting the agricultural sectors would have a greater impact on rural household's income than on the capitalist's income.

3.3 Structural Path Analysis and Examples of SAM Multiplier Applications

The SAM framework represents an important addition to, and generalization of, the input-output model since it captures the circular interdependence character of any economic system among a) production activities, b) the factorial income distribution, and c) the income distribution among institutions (particularly among different socioeconomic household groups), which, in turn, determines the expenditure pattern of institutions (i.e. the triangular scheme shown in Figure 2). The global (direct and indirect) effects of injections from exogenous variables on the endogenous variables are captured, under certain conditions, by the fixed price and constrained multipliers. However, these multipliers do not clarify the "black box," i.e. the structural and behavioral mechanism responsible for these global effects. From a policy standpoint, knowledge of the magnitude of multipliers is important but becomes of even greater operational usefulness if it is complemented by structural path analysis that identifies the various paths along which a given injection travels. In particular, structural path analysis reveals, in contrast to multipliers per se which are scalar numbers, the specific individual sectors (activities, factors and household groups) through which influence is transmitted in a socioeconomic system represented by the SAM. Structural path analysis provides a detailed way of decomposing multipliers, and of identifying the whole network of paths through which influence is transmitted from one sector of origin to its ultimate destination thereby opening the black box (see Defourny and Thorbecke, 1984).

An example of the essentially triangular channels of influence can be given to illustrate this concept before presenting it more formally. Assume that we are interested in explaining the main paths through which a new textile factory in a rural site affects directly and indirectly the incomes of small farmers. The increase in textile output will require unskilled labor that is to be provided by two different household groups, i.e. small farmers and the landless. Because these two groups are likely to be poor, a significant part of the incremental incomes accruing to them from earnings from work in the factory will be spent on food crops. The subsequent increase in food crop production, in turn, requires unskilled family labor from small farm households, thus further raising their incomes. In this example, the following paths spanning textiles output, as the pole of origin, and incomes of small farmers, as the pole of destination, can be identified: 1) a relatively direct path from larger textile production to demand for unskilled labor supplied by small farmers, to incomes accruing to small farmers' households; and 2) a more indirect path from increased output in the textile sector, to increased demand for unskilled labor (as a factor of production), to increased expenditures on food, to increased demand for labor supplied by small farmers, to increased incomes accruing to small farmers' households. The multiplier value, which is a scalar measure of global influence between given poles of origin and destination, can be decomposed into the sum of total influence traveling along the different paths spanning these two poles (i.e. in the previous example, textile production and incomes of small farmers).

The SAM methodology has been extensively used to analyze a variety of different questions at different levels of geographical aggregation. First, in developing countries at the national level it has been used to explore such issues as, for example, 1) the impact of a variety of government expenditure patterns and commodity compositions of exports on income distribution in Indonesia, e.g. Keuning and Thorbecke, 1989; 2) a changing structure of production and alternative technologies on employment (e.g. the dualistic SAM built by Khan and Thorbecke, 1989, to compare the employment impact of traditional and modern technologies in Indonesia); 3) the impact of environmental policies on output, household incomes and health (Resosudarmo and Thorbecke, 1996); 4) intersectoral linkages (e.g. a SAM of Mexico to explore the intersectoral impacts of alternative adjustment strategies by Adelman and Taylor, 1990; and the impact of intersectoral linkages on rural poverty alleviation: Thorbecke, 1995); and 4) food consumption (e.g. Hay, 1978, work on a Food Accounting Matrix).

In industrialized countries, at the national level the SAM methodology has been used to analyze, and has been applied to such issues as the effects of different taxation and subsidy schemes on income distribution (e.g. a detailed SAM for the U.S. built by Reinert and Roland-Holst, 1992); the impact of alternative tariff structures on the pattern and composition of imports and exports as well as the resulting structure of output and employment (e.g. Reinert and Roland-Holst, 1989, who built a U.S. SAM for trade policy analysis); and a whole set of intersectoral, interregional and environmental questions.

At the regional level, SAMs have been built for a number of U.S. States to study most of the above issues, but at a lower level of geographical aggregation (e.g. a SAM for Oregon by Waters and Holland, 1996). Another example of a State SAM is that built by Kilkenny and Falide (1996) for Iowa to explore in a very comprehensive and disaggregated way the impact of federal, state and local taxes and spending on counties and other regional entities within Iowa. Kilkenny and Falide (1996) call their SAM a multi-regional, multi-jurisdiction fiscal SAM.

Similar efforts in Third World countries, mainly at the provincial or district level, highlighted intersectoral linkages particularly between agricultural and nonagricultural activities and interregional linkages with the rest of the country and the rest of the world (e.g. Lewis and Thorbecke, 1992 work on the Kutus district of Kenya).

Finally, at the village level, most if not all applications so far have been to settings of developing countries. A recent book by Taylor and Adelman (1996) on Village Economies presents five village SAMs from different parts of the world and uses these SAMs to explore a variety of issues. As the authors point out, most of the world's population and the vast majority of the world's poor live and work in villages. Their activities are usually centered in households, but interactions among households shape the impacts of policy, market, and environmental changes on rural production, incomes, employment, and migration. Their book presents a new generation of village-wide economic modeling based on SAMs. Village SAMs have analyzed such diverse issues as the impact of remittances from Mexican workers abroad or in urban centers to their families on the standards of living of various socioeconomic groups in those villages (Adelman, Taylor and Vogel, 1989); the impact of a factory on the outskirts of a village on employment, incomes and the modernization trend within the village (e.g. Parikh and Thorbecke, 1996, SAM of two Indian villages to explore the impact of decentralized rural industrialization on village life); and nutritional consequences of different exogenous policies (e.g. Ralston, 1996 work on household nutrition and economic linkages applied to a village in West Java).[7]

4. SAM-Based General Equilibrium Models

4.1 From SAMs to Computable General Equilibrium Models

The preceding SAM multiplier analysis rests on some limiting assumptions, namely that excess capacity prevails and unused resources are available. Under this type of Keynesian world, any exogenous increase in demand can be satisfied by a corresponding increase in supply while maintaining constant prices. The comparative

[7] A number of these SAM-multiplier applications are discussed in detail in Thorbecke (1998).

static nature of the SAM multiplier analysis, as such, precludes capturing and estimating dynamic effects. For example, whereas investment demand (i.e. the intermediate inputs, labor and capital required in the construction phase of a project) is explicitly incorporated in the SAM, the future effects of investment on productivity are ruled out by the fact that a SAM is only a one-year snapshot of the economy.

However, a more likely world (and set of conditions) is that at least some sectors in the economy operate at full capacity and some factors of production (e.g. skilled labor) are fully employed. Under those circumstances prices can no longer be assumed to remain constant. In a Computable General Equilibrium (CGE), prices are endogenously determined so as to generate the set of prices that are consistent with "equilibrium" in an economy. When an economy is affected by an exogenous shock or a policy change, a new set of prices obtains, which, in turn, determine production, consumption, employment and incomes.

Both SAM multiplier modeling and CGEs are based on two fundamental pillars, i.e., that interaction and interdependence within a socioeconomic system matters as does the prevailing structure. What CGEs add to the simple SAM framework is that they capture the behavior of the main actors in response to price changes.

The SAM provides the underlying taxonomy of the CGE. Each account and subaccount of a given SAM appears as a corresponding endogenous or exogenous variable in the CGE based on that SAM. Not only does a CGE take as its initial conditions the values appearing in the base-year SAM but, in addition, the parameters and coefficients of the various equations of the CGE are calibrated on the base-year SAM. In this sense, it can be said that a SAM provides the "navigation table" for a CGE. All the mechanisms and transformations inherent in the SAM and described in detail in Section 2 are an intrinsic part of the CGE's architecture, as well. The SAM structure predetermines the channels (i.e. the various transformations) through which influence is transmitted throughout the socioeconomic system and the CGE formalizes the relationships underlying these channels through a set of behavioral and technical equations and equilibrium conditions.

A general equilibrium model has been described in terms of the following components: 1) the economic sectors or agents whose behavior is to be analyzed have to be specified as well as the behavioral rules reflecting their assumed motivations (e.g. producers typically maximize profits subject to technological constraints and households maximize utility subject to income constraints); 2) agents make their decisions according to signals they observe such as prices; 3) the "rules of the game" according to which agents interact (e.g. is the institutional structure of the economy one of pure competition?); and 4) "equilibrium conditions" have to be satisfied (Robinson, 1989).

The specification of a CGE should not only reflect the prevailing socioeconomic structure of the economy (i.e. the classification scheme in the base year SAM should be consistent with that structure) but also the behavior of the actors and the constraints they face. Hence a typical CGE starts with a set of neo-classical rules and modifies them to reflect the idiosyncratic environment specific to the setting that is described.

A key issue relates to what method should be used to select appropriate behavioral and technological parameters and coefficients in the equations that constitute a CGE. Should the parameters be estimated statistically or more simply directly calibrated on a base-year SAM? A recent survey argued cogently that, although there are two schools of thought on this issue, "calibration is estimation [and] estimation is calibration" (Dawkins, Srinivasan and Whalley, 1999). They argue that

> if calibration is the setting of the numerical values of model parameters relative to the criterion of an ability to replicate a base case data set as a model solution, and estimation is the use of goodness of fit criterion in the selection of numerical values of model parameters, the two procedures are closely related. (Dawkins, Srinivasan and Whalley, 1999, p. 15)

It can be argued that, at least to some extent, relying exclusively on a SAM to calibrate the parameters of a CGE model places the analyst in somewhat of a "straightjacket." That is why, in some instances, a hybrid approach, where some parameters are statistically estimated and others calibrated may be more realistic and provide more flexibility. Examples of such macroeconomic models are presented subsequently.

The most typical procedure is to calibrate a CGE directly on the base-year SAM. This can be illustrated by referring back to the SAM of an archetype African economy discussed in detail in Section 3.2. A CGE was built and fully calibrated on the basis of this SAM to explore the impact of trade liberalization on the economy and ultimately on poverty (Decaluwe, Patry, Savard, and Thorbecke, 1999). This model of an archetype African economy consists of CES production functions for the six activities appearing in Table 3; demand functions by the six household groups for the five commodities, respectively, using a linear expenditure system; income and savings functions for all institutions, a foreign trade module and a set of definitional equations and equilibrium conditions. For example, the share parameters in the production functions were taken directly from Table 4 (the matrix of average expenditure propensities) as were the propensities to consume of the six household groups for the five commodities in calibrating the expenditure system of the model.

The use of a benchmark year for model calibration (i.e. reliance on the structure prevailing in a single year) raises the issue on whether the benchmark year represents a "normal" year. Clearly, if the SAM is based on an anomalous year, the parameters derived from it can not be considered representative of the underlying structure.

Another crucial issue in constructing a CGE relates to the closure rules that are selected. For example, are savings endogenously determined so that the model is savings-driven with investment adjusting to savings ex post facto or, alternatively, is the model investment-driven with savings forced to equate investment. Another key closure rule relates to the balance of payments. Under a fixed exchange rate regime imports cannot exceed exports and the net inflow of capital, while under a flexible exchange rate regime the latter is endogenously determined to equilibrate the demand for foreign currency with its supply. Likewise, some markets can be modeled to operate perfectly (through price adjustment), whereas other markets, such as those for certain types of labor, can be modeled to operate imperfectly by allowing some unemployment. Clearly, the closure rules adopted in a CGE model should reflect the prevailing institutional and policy framework and be faithful to the observed behavior of markets and agents.

4.2 Brief and Selective Review of Applied General Equilibrium Models

The great majority of general equilibrium models were built for simulation as opposed to projection purposes. Likewise, most CGEs are essentially static (or comparative static) models. Conceptually, they can be thought of as starting with initial conditions given by a base-year SAM and generating a new SAM representing the new equilibrium following an exogenous shock or reform. The major raison d'être of those models is to explore the likely impact of shocks, crises, or policy changes and reforms on the economy. In particular, analysts and policymakers are interested in direct and indirect effects of alternative (exogenous and policy) counterfactual scenarios. In this sense, the model becomes the economist's analogue of the biologist's laboratory.

The domain of a CGE can vary from village, to district, to region, to interregional, to national, all the way to international (as in the case of global trade models). Thus, for example, Taylor and Adelman (1996) used the five village SAMs appearing in their "Village Economics" volume mentioned previously to build complementary CGEs calibrated on the latter and designed to capture the impact of policy, market and environmental changes on the respective village economies.

Before undertaking a brief review of general equilibrium models with specific emphasis on the Third World, we need to specify some organizational criteria. The first one would appear to be to distinguish models according to the type of shock or crisis faced and policy changes and reforms to be simulated. By assumption, external shocks are typically taken as exogenous, as are policy changes. Whereas this assumption is noncontroversial in the simulation of shocks (such as a sudden increase in the prices of imports or a drought), many economists would argue that policies and reforms are largely endogenously determined given the prevailing institutions and political balance of power. This would certainly be the view of the "Public Choice" school. Such models could, in principle, be built but require a knowledge of the political economy that is very difficult to specify quantitatively. A second organizational criterion that suggests itself is the nature of the issues to be explored and what part of the socioeconomic system (i.e. captured by the SAM) is to be focused on.

Thus, examples of shocks that have been modeled include 1) trade shocks such as sudden changes in the international terms of trade faced by a given country or a sudden fall in exports; 2) droughts; 3) technological changes; and 4) financial crises such as those suffered by Mexico in 1992 and the East Asian economies in 1997. In turn, examples of policy changes and reforms that have been simulated using CGEs include 1) the impact of trade liberalization and tariff harmonization on efficiency, the structure of production and employment; 2) the impact of structural adjustment and stabilization policies on income distribution; 3) the impact of a variety of sectoral policies (e.g. in agriculture, education and health) on output, food security and the distribution of benefits received; 4) the effects of public investment (including that of large scale physical infrastructure projects, such as dams) on output and income distributions; 5) the consequence of environmental policies on the structure of production and health; 6) the impact of multilateral trade negotiations and agreements (e.g. the Uruguay round) on the world trade pattern; 7) the impact of various taxation schemes on income distribution; 8) the interregional consequence of alternative public investment, taxation and subsidy scenarios.

Given the enormous multiplicity of SAM-based CGE models it would take a large volume to review and analyze them comprehensively. Hence, this paper limits itself to a highly selective review of two prototypical CGE applications in the Third World.

The first example is based on a CGE model calibrated directly on the SAM of an archetype African economy, discussed in some detail, previously in Section 3.2. The major objective of this model was to explore the impact of two different exogenous shocks (a fall in the price of exports and a reduction in tariffs) on poverty (see Decaluwe et al., 1999).

The CGE model takes as its point of departure the initial intra-group income distributions for the six different household categories appearing in the SAM of the Archetype African economy (see Table 3) and in the model. The model specifies the initial (base-year) income distributions of each of the six household groups (a task which is presently feasible based on the increasing availability of large-scale household income and expenditure surveys in practically all countries). Other features of the model are that the poverty line is defined as the cost of a basket of basic needs commodities. Since the basket itself remains invariant, in quantitative terms (consistent with the notion of absolute poverty), and prices are endogenously determined within the model so is the monetary poverty line. The demand system adopted in the CGE model is a variant of the Linear Expenditure System. Demand functions are specified for each socioeconomic household group and for each commodity. The form of these functions is that they contain a subjectively derived minimum commodity basket specific to each household group and reflecting the socioeconomic characteristics of each group and its standard of living and preferences.

Starting with the initial intra-group income distributions the model simulates the effects of two different shocks on the average income levels of the household groups and assumes that the initial distributions shift horizontally (either to the left or to the right) as mean incomes fall or rise, respectively. This procedure yields the post-simulation within-group distribution, which can then be confronted with the new endogenously derived poverty line to measure the resulting poverty — using the F-G-T additively decomposable class of poverty measures. In this way a comparison can be made of the incidence of poverty in the pre- and post-simulation situations. Figure 3 illustrates the effects of a 50% reduction on import tariffs on poverty for each of the six household groups.

In short, the approach followed in this model goes part of the way in endogenizing the effects of exogenous shocks on poverty within a general equilibrium framework. A better understanding of those mechanisms affecting the shape of intra-group income distributions following a shock would reduce the arbitrariness of assuming that those distributions shift horizontally so that every individual within a household group receives an addition (or, alternatively, a reduction) in income equal to the difference between the post- and pre-simulation average income of that group.

The next example of the use of CGEs addresses what is probably the most important contemporaneous development issue, namely, that of the impact of structural adjustment and stabilization policies on income distribution. The two best known research programs that analyzed those issues with the help of CGEs are the OECD Development Center program on "Adjustment and Equity" and the Cornell University program on the effects of adjustment on poverty in SubSaharan Africa. By using country-specific general equilibrium models reflecting the underlying structure and behavior of the major actors (including the government) the impact of counterfactual scenarios, including the consequences of the country not adjusting or only marginally adjusting could be simulated. Under the OECD project, six country models were built and, in general, it was found that adjustment was not necessarily inconsistent with a more equitable income distribution (Bourguignon and Morrisson, 1992). Likewise, the Cornell project based on five CGE models (Cameroon, Gambia, Madagascar, Niger and Tanzania) concluded that adjustment had not hurt the poor (Sahn, Dorosh and Younger,

Figure 3a–3f: Effect of a 50% reduction in import tariffs on all imports

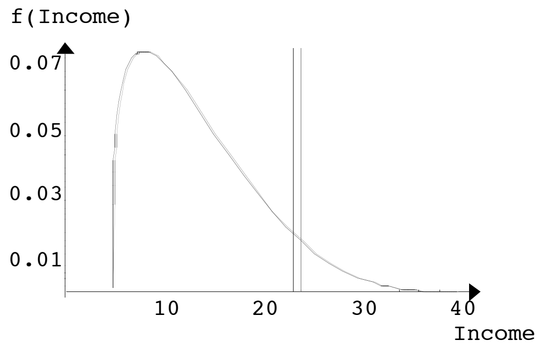

Figure 3a : Income distribution rural households

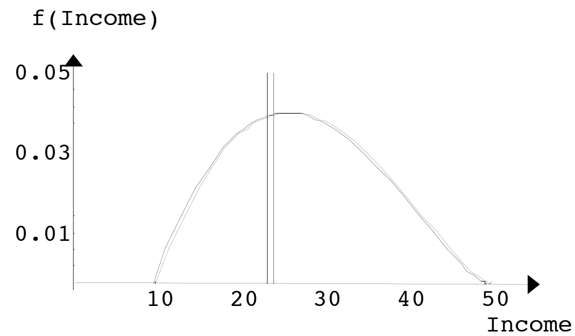

Figure 3b : Income distribution small landowner households

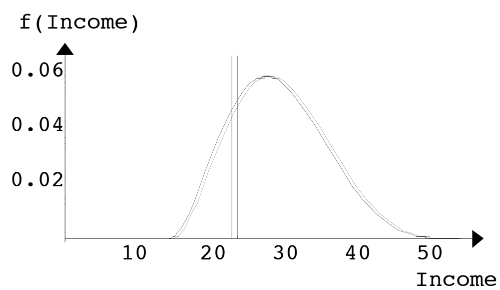

Figure 3c : Income distribution large landowner households

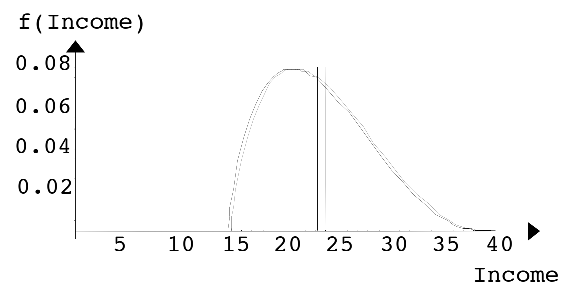

Figure 3d : Income distribution urban low education households

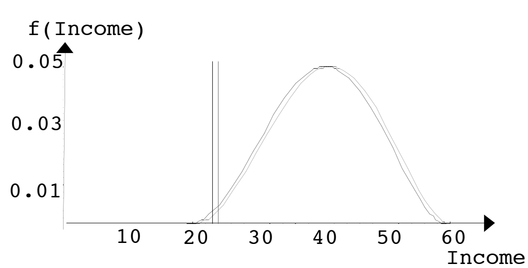

Figure 3e : Income distribution urban high education household

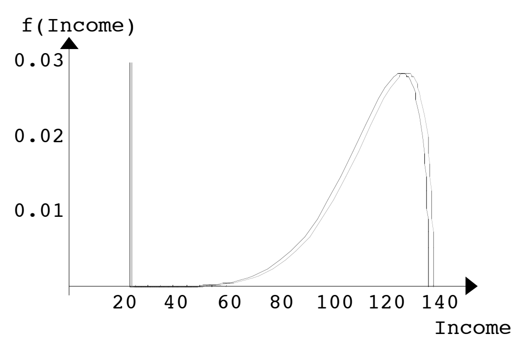

Figure 3f : Income distribution capitalist households

Source: Decaluwe et al. (1999).

1996). Each of the models built under the auspices of OECD and Cornell relied on a carefully prepared SAM.

A main advantage of the CGE methodology is that it potentially corrects for the major conceptual drawback of the "before and after" approach. Thus, a worsening of socioeconomic conditions and equity after adjustment as compared to the prevailing situation before adjustment cannot necessarily be ascribed to, and causally linked to adjustment policies. It is quite possible in a counterfactual sense, that the conditions might have deteriorated even more in the absence of managed adjustment. It is useful to explore briefly the structure and major features of the prototypical models developed under the OECD project. The Indonesian model (Thorbecke, 1992, and Thorbecke, 1991) integrates a real and a financial sector. Building such a model required the specification of a financial SAM in addition to a real SAM. The model was built to replicate the conditions prevailing in the Indonesian economy between 1982 and 1988 (the adjustment period). The financial SAM contains the same classification of households and production activities (to be exact, firms supplying those activities) as in the real SAM. It also includes five other institutions: firms (as indicated above), commercial banks, the central bank, government and the rest of the world. The initial (base-year) portfolio of assets (consisting of currency, demand deposits, time deposits, foreign deposits, equity and foreign bonds) owned by each institution is given in the financial SAM. The construction of the financial SAM was a major task without which the financial part of the model could not have been calibrated.

A particular strength of the Indonesian model is the detailed treatment of government expenditures (divided into 12 categories by sector of destination). Here again the richness of Indonesian statistical data permitted the incorporation of a detailed public finance module in the SAM and ultimately in the model (based on Keuning and Thorbecke, 1989). Other noteworthy features of the Indonesian model are a segmented labor market specification with endogenous sectoral wage equations (with wage rates specified as a function of inflation, the sectoral output prices, and labor productivity growth, respectively); an endogenously determined private investment function depending on output in the previous and current periods and the lending interest rate; a hierarchical decision making process in the selection of the portfolio of assets by the various institutions; and, finally, a balanced budget institutional constraint prevailing in Indonesia at that time. Furthermore, in contrast with the great majority of general equilibrium models, many of the behavioral parameters and coefficients were statistically estimated on the basis of time series observations. In this sense the model can be considered as a hybrid CGE-macroeconomic model.

The complete model consists of 86 equations which, when disaggregated by sector, types of institutions, and factors, yielding more than 600 equations. The model was used to simulate six alternative policy scenarios (combinations of different government expenditure patterns, currency devaluation, and monetary policy). A comparison of the results of the simulation of the alternative policy scenarios revealed that the policy package actually adopted and implemented by the government helped restore internal and external equilibrium without worsening the distribution of income. Whether by accident or design (the latter is more probable), the package of adjustment measures actually implemented appeared almost optimal under the socioeconomic constraints faced by the government.

5. CONCLUSIONS

This paper has described in detail the contribution of the SAM methodology to modeling, The SAM is a comprehensive, disaggregated and consistent data system that captures the interdependence that exists within a socioeconomic system during a given period of time. Thus, depending on the classification scheme used to record transactions and the extent of disaggregation, the SAM can provide useful information about such key issues as intersectoral linkages (such as between agriculture and industry), the determination of the income distribution by socioeconomic groups given the structure and technology of production and the resource endowments of these groups.

Alternatively the SAM can be used as a conceptual framework to explore the impact of exogenous changes such as a variety of shocks (e.g. trade shocks, droughts, financial crises) and policy changes and reforms (e.g. structural adjustment and stabilization) on the whole interdependent socioeconomic system. As such, the SAM becomes the basis for simple multiplier analysis and the building and calibration of a variety of general equilibrium models. Although the assumptions under which SAM multiplier analysis is valid tend to be rather heroic (i.e. that any increase in exogenous demand is to be satisfied by a corresponding increase in output) calling for a Keynesian world in which excess capacity and unused resources prevail and prices remain constant, the taxonomy and format of a given specific SAM define and predetermine the channels through which influence is transmitted within the socioeconomic system captured by that same SAM.

The usefulness of SAM multiplier analysis should not be judged by the extent to which given multiplier values approximate closely or not the actual impact of exogenous shocks or policy changes but rather in how well it captures the full set of channels and paths through which influence travels within the socioeconomic system. Structural path analysis allows the identification of the various paths through which influence is transmitted and, as such, provides a transparent way to explain to policymakers the channels through which a shock or a reform affects their economies.

General equilibrium models add realism to the SAM-multiplier methodology by allowing prices to be endogenously determined and by incorporating certain structural and institutional characteristics affecting the functioning of markets and the behavior of actors. At the same time, to the extent that those models are calibrated on a benchmark SAM, they incorporate the taxonomy (i.e. the variables) of the underlying SAM and all the channels and transformations appearing in the latter. In that sense the SAM provides and predetermines the road map or the navigation table that endogenous variables (in this metaphor, cars or ships) have to follow in a specific setting. By analogy, the actual motion of the latter is given in the corresponding model by the behavioral and technical equations and closure rules. A realistic SAM reflecting well the structure of a socioeconomic system is a necessary but not a sufficient condition to a sound CGE.

It has to be recognized that CGEs, in general, are relatively blunt, inflexible instruments and not very customer-friendly; requiring experienced and mature analysts to translate their results so that they are operationally useful to policy makers. Although it still may be the best method yielding counterfactual results, one can agree with the conclusion reached by a recent critical evaluation of CGE models by De Maio, Stewart and van der Hoeven (1999):

> We believe there is a place for CGE models. . . . They need to be accompanied, however, by extensive use of sensitivity analysis to test how far the conclusions depend on particular assumptions; by consistent, careful, empirical checking of parameters and functional forms; by appropriate categorization of groups for poverty analysis; and by continuous monitoring of the actual changes, checking these against the predictions of the models. (p. 465)

At the same time it is no exaggeration to claim that the SAM methodology as a data system and conceptual framework has proven to be robust and lasting and very useful to statisticians, economists and policy analysts. The dissemination and diffusion of the SAM methodology over the last three decades has been remarkable — as the multiplicity of applications testifies. By now there are very few countries left for which no SAM, at the national, regional or village level, exists. Greater interaction between the SAM community and the modeling community would further enhance the operational usefulness of both approaches.

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