CHAPTER 5

SOCIAL ACCOUNTING MATRIX THEORY (SAM)

5.1 Introduction

Chapter 4 described the use of a partial equilibrium framework in policy analysis. It was, however, observed that this analysis is only applicable at sectoral and commodity levels and therefore does not provide a complete picture of the economy-wide effects following policy changes. Similarly, the partial equilibrium approach overlooks sectoral linkages and income and expenditure relations that are normally found in an economy. To complement the partial equilibrium framework, this chapter describes the theory of a Social Accounting Matrix (SAM) that does capture the linkages and income and expenditure relationships in an economy.

Further, this chapter describes the SAM income and price multipliers and the steps used to derive them. The SAM multipliers will be used to measure the economy-wide effects of trade liberalization and market access on household food security/welfare and the competitiveness of the agricultural sector in Botswana in Chapters 7 and 8. The present chapter also provides empirical evidence concerning the use of economy-wide or SAM-based policy models in international trade liberalization. The merits and demerits of economy-wide approaches are also covered.

5.2 A description of a SAM

A social accounting matrix (SAM) constitutes a “circular flow of income around the familiar macro-economic loop of demands on activities, leading to demands for factors, hence to the incomes of institutions, and from there back to demands on activities” (Pyatt and Round, 1985, p.9). As the current study is, *inter alia*, interested in food security including the welfare of consumers, a

SAM-based analysis also enables one to measure the effects of international trade liberalization on household income by socio-economic group, factor, sector/production activity, etc. In fact, SAM as a technique illustrates that the distribution of employment and income opportunities and hence a society's living standard is "inextricably interwoven with the structure of production and the distribution of resources" (Pyatt and Round, 1985, p.2).

A social accounting matrix is primarily concerned with the organization of information about the economic as well as the social structure of a country in a particular year. The provision of this statistical base also enables a country to develop economic models through which policy analysis and decisions can be made. A schematic illustration of a basic SAM is presented in Figure 5.1. A SAM is a square matrix with rows and columns. Rows represent income/receipts while columns cater for expenditure/payments.

Besides analyzing the interrelationships/interdependence of various accounts as indicated in Figure 5.1, a SAM views the aggregate economy as a complex interaction of interdependent activities, since outputs of one activity form part of the raw materials/inputs of the other (Pyatt and Round, 1985). In the matrix the rows are aggregated according to commodity, activity, factor, household, institution and government, capital and the rest of the world receipts or incomes while along the columns expenditures of the same accounts are represented.

Total income from each account, say commodities or factors, must equal total expenditure for the same account. Specifically, row totals for each account must equal the column totals of that account. There are six main accounts in the SAM. These are activities, commodities, factors, institutions, capital and the rest of the world. Government, as distinct from an administrative activity, can be separated from institutions and be made an account on its own in conformity with macro-economic theory. In this scenario, government spends on its current and capital accounts and also receives tax revenues and transfers abroad. Figure 5.1 below illustrates the structure of a SAM covering the accounts indicated above.

	Expeditures									
Incomes	1	2	3		4			5	6	7
			Factors		Institutions			Capital	Rest of	
	Activities	Commodities	Labour	Capital	Households	Firms	Government	Account	World	Total
1 Activities		Domestic sales					Export Subsidies		Exports	Production
2 Commodities	Intermediate demand				Households consumption		Government consumption	Investment		Domestic Demand
3 Factors										
labour	wages								Factor incomes from abroad	Gross national product at factor cost
4 Institutions										
Households			Labour income	Distributed profits	Intrahousehold transfers	Transfers	Transfers		Transfers	Households income
Firms				Nondistributed profits	Transfers		Transfers		from	Firms income
Government	Value-added taxes	Tariffs ind.taxes	Taxes Social sec.	Taxes on profits	Direct taxes	Taxes			abroad	Government income
5Capital account					Households savings	Firms savings	Government savings		Capital transfers	Total savings
6Rest of World		Imports	factor payments			Current transfers abroad				Imports
7 Total	Production	Domestic supply	Factor outlay		Households expeditures	Firms expeditures	Government expeditures	Total investment	Foreign Exchange earnings	

Source: Sadoulet and de Janvry, 1995, p.275

Figure 5.1: The Structure of a Social Accounting Matrix (SAM)

Figure 5.1, under activities (across row 1), illustrates that receipts or income are gained from sales on the domestic market, exports and government subsidies, the row total gives the aggregate value of production. Activity expenditure (column 1) covers the purchase of intermediate inputs, payment of factors (land, capital, labour, etc) and remitting taxes to government. The column total for activities represents as aggregate expenditure.

On the commodity account (maize, wheat, beef, milk, fruits, vegetables, sugar, diamonds, etc), receipts or income are gained from the domestic market through the purchase of intermediate raw materials by activities, consumption by households and government and as investment goods of the capital account. The purchase of commodities by activities to make finished goods, etc is also known as the use or absorption matrix. The row total for the commodity account accounts for domestic demand. On expenditure, the commodity account shows purchases of domestically produced goods by activities and payment of indirect taxes, including import duties, by government, excluding public subsidies on commodities. Payments made by the commodity account for goods domestically produced by activities are also known as the make matrix. The column total for commodities represents domestic supply. Both the use/absorption and make matrices are central to the conventional Leontief input-output tables or inter-industry interactions. Input and output tables are made up of commodity and activity accounts only (Sadoulet and de Janvry, 1995, p.285). As a result, the income and expenditure relations in the economy with institutions, government and international transactions are not captured in input and output accounts/tables. In order to capture the full impact of external policy impact on the economy as illustrated in Figure 5.1, income and expenditure flows between institutions such as households, government and the rest of the world, are included in the conventional input-output accounts (Francois and Reinert, 1997, p.96). Infact input-output tables or accounts are a subset of a SAM.

Insofar as the factor account is concerned, receipts (across row 3) are derived from the activity account as payment of their services (wages, rent, etc), as well as from remittances from abroad. The row total for the factor account forms the country's gross national product at factor cost. Factor revenue is distributed to households as labour income, while profits after government tax are retained by firms/companies. Total expenditure by the factor account is classified as factor outlay.

Households as institutions receive income (row 4) by factors, transfers from other households, government, other firms, and from abroad as remittances. Expenditure by households (column 4) includes current consumption, income taxes and savings. Firms, as part of institutions, obtain their income from profits and transfers, and spend the income on paying taxes as well as transfers. As with households, residual savings by firms contribute to the country's capital account. Government receives income from taxes and also current transfers from abroad, as foreign assistance.

On the capital account, receipts or income are derived from savings by institutions such as households, firms and government, as well as transfers from abroad. Income from the capital account is spent as the country's total investment.

For an open economy, transactions take place with other parts of the world. Payments by the rest of the world for the country's exports, such as diamonds and beef, constitute imports for the rest of the world. Furthermore, foreign exchange earnings are obtained by means of factor income from abroad and transfer from abroad, including capital transfers. In turn, the rest of the world pays for imports and for factors abroad, as well as for other transfers abroad. The column total for the rest of the world's transactions accounts for the country's imports foreign exchange earnings.

Each of the accounts in Figure 5.1 can be disaggregated into sub-accounts. Further, when the SAM multiplier analysis is to be undertaken, it is necessary to determine which accounts are endogenous and which are exogenous. This study will use both SAM income and price multiplier analysis to assess the effects of international trade liberalization on food security and competitiveness of the agricultural sector in Botswana. Endogenous accounts comprise those that can be influenced within the system or those whose level of expenditure is directly influenced by changes in income, while exogenous accounts constitute those whose expenditures are independent of the changes in income (Sadoulet and de Janvry, 1995, p.288). The standard practice is normally to treat government, capital and the rest of the world accounts as exogenous accounts. This classification will be followed when analyzing Botswana's SAM in Chapter 7.

5.3 Justification for using a SAM-Multiplier Analysis

As indicated in Chapter 1, this study will mainly apply the Social Accounting Matrix (SAM) multiplier analysis, in order to understand the sector- and economy-wide effects of international trade liberalization on food security and competitiveness of agriculture in Botswana. The SAM multiplier analysis has been chosen over the conventional Leontief Input-Output model because of its special features, which the latter does not indicate. In particular, the Input-Output model, although a general equilibrium model, only examines the relationships between the production accounts, while other accounts like factors of production, institutions, capital and the rest of the world are not fully captured (Pyatt and Round, 1985, p.33).

Further, the Input-Output models analyze inter-industry flows or interactions, but the interdependence of or interrelationships among various accounts, as well as interactions within accounts or sub-sectors, are not captured by the Input-Output models (see Figure 5.1). Leontief Input-Output models basically examine the amount of one sector's output that is required for the production of output in another sector (Sadoulet and de Janvry, 1995, p.285). Unlike Input-Output models, the SAM comprehensively covers the interrelationships between and among accounts. Chapter 6 will demonstrate these linkages using the reduced 1993/94 SAM for Botswana.

When SAM multipliers are compared with the input-output multipliers, the former are seen to be larger. Multipliers refer to coefficients in the various columns generated by changes in any of the exogenous accounts. For instance, if exports were treated as an exogenous account from the "Rest of the World" account, the multiplier in this case is a coefficient of the effect of a change in exports on the various endogenous accounts. Whereas in the input-output analysis intermediate demand for inputs serves as a multiplier, in the SAM, the value added and incomes generate demand linkages, hence the larger multipliers in the latter" (Sadoulet and de Janvry, 1995, p.291).

In fact, in a study examining the effect of an increase in agricultural exports (exogenous account) on the economy of Ecuador, a country in Latin America, it was found that the SAM multipliers were significantly greater than those of the Leontief Input-Output analysis. Specifically for activities, commodities, labour and household income, the SAM multipliers were, in most cases, twice as great as those from the Input-Output analysis because the former capture the income and demand linkages while the latter do not.

Based on Input-Output analysis, it has been observed that since agriculture exhibits low production multipliers, this has unfortunately led to a bias in investment policy against this sector, while industry/manufacturing was favoured instead (Sadoulet and de Janvry, 1995). The low production multiplier in agriculture is caused by the weak income linkages and value added. These two linkages are not captured fully in the input-output analysis, unlike the SAM approach. Generally, industry exhibits greater production linkages through intermediate demand than agriculture. Other models such as the multi-market model are essentially partial equilibrium models that analyze only sector-wide effects. In particular, multi-market models capture the interactions between, for instance, the changes in prices of maize and the effect on beef/wheat production or vice versa.

5.4 SAM-Leontief Models

In this study, two types of SAM multipliers will be described since these will be used in Chapter 7 to evaluate the effects of trade liberalization and market access on food security, household welfare and agricultural competitiveness. Below is a brief description of these multipliers.

5.4.1 Accounting/Income Multipliers

Table 5.1 illustrates different matrixes in the SAM. Matrix N represents outlay transactions between endogenous accounts (factors, institutions and production/activities) and matrix L shows leakages from endogenous accounts into exogenous accounts (government, capital and the rest of the world). The x matrix represents injections of income from exogenous accounts into endogenous ones and t is the matrix of expenditure transactions between exogenous accounts. As was indicated in the discussion of figure 5.1, the respective column and row totals must be equal.

Table 5.1: The SAM model summarized by endogenous and exogenous accounts

Receipts (Revenue)	Expenditures (Outlays)		Total
	Endogenous Accounts	Exogenous Accounts	
Endogenous Accounts	**N**	**X (injections)**	y_n
Exogenous Accounts	**L (leakages)**	**T**	y_x
Totals	y_n'	y_x'	

From Table 5.1 for any matrix $\tilde{\mathbf{A}}_n$ of the same size as A_n, such that $(1- \mathbf{A}_n)^{-1}$ exists, we can write

$\mathbf{y_1 = A_n.y_n + x}$

$\mathbf{y}_1 - \mathbf{A}_n.y_n = x$

$\mathbf{(1 - A_n)\, y_n = x}$

$\mathbf{y_1 = (1 - A_n)^{-1}\, x = M_{ax}}$

This equation shows the incomes ($\mathbf{y}_n$) for the factor, household/institutional and production/activity accounts that are endogenously determined following exogenous injections. The inverse, $(1- \mathbf{A}_n)^{-1}$, is termed an accounting multiplier matrix, $\mathbf{M}_a$. This multiplier matrix relates endogenous incomes y_n to injections, x. $\mathbf{A}_n$ represents the matrix of average endogenous expenditure propensities. If given the equation, $y_n = \mathbf{A}_n.y_n + x$ as indicated above, it follows that for any matrix **A~n** of the same size as $\mathbf{A}_n$ and such that the inverse $(1 - \mathbf{A\sim n})^{-1}$ exists, we can write

$$
\begin{aligned}
y_n &= A_n y_n + x \\
&= (A_n - \tilde{A}_n) y_n + \tilde{A}_n y_n + x \\
&= (I - \tilde{A}_n)^{-1} (A_n - \tilde{A}) y_n + (I - \tilde{A})^{-1} x \\
&= A^* y_n + (I - \tilde{A})^{-1} x
\end{aligned}
$$

Multiply the right hand side by $\mathbf{A}^{*}$ which gives

$$y_n \;=\; A^{*2} y_n \;+\; (I + A^{*})(I - \tilde{A}_n)^{-1} x \tag{1}$$

Multiply both sides by $\mathbf{A}^{*2}$ and rearranging to solve for y_n gives

$$\begin{aligned} y_n &= A^{*3} y_n + (I + A^{*} + A^{*2})(I - \tilde{A}_n)^{-1} x \\ &= (I - A^{*3})^{-1}(I + A^{*} + A^{*2})(I - \tilde{A})^{-1} x \end{aligned} \tag{2}$$

A_n and $\tilde{A}_n$ can be written as

$$A_n = \begin{bmatrix} 0 & 0 & A_{13} \\ A_{21} & A_{22} & 0 \\ 0 & A_{32} & A_{33} \end{bmatrix} \quad \text{and} \quad \tilde{A}_n = \begin{bmatrix} 0 & 0 & 0 \\ 0 & A_{22} & 0 \\ 0 & 0 & A_{33} \end{bmatrix} \tag{3}$$

and hence

$$A^{*} = \begin{bmatrix} 0 & 0 & A_{13}^{*} \\ A_{12}^{*} & 0 & 0 \\ 0 & A_{32}^{*} & 0 \end{bmatrix} \quad where \quad \begin{pmatrix} A_{13}^{*} = A_{13} \\ A_{21}^{*} = (I - A_{22})^{-1} A_{21} \\ A_{32}^{*} = (I - A_{33})^{-1} A_{32} \end{pmatrix} \tag{4}$$

Three multipliers can then be defined

$$\begin{aligned} M_{a1} &= (I - \tilde{A}_n)^{-1} \\ M_{a2} &= (I + A^{*} + A^{*2}) \\ M_{a3} &= (I - A^{*3})^{-1} \end{aligned} \tag{5}$$

of which the product is the aggregate SAM multiplier first derived as

$$\begin{aligned} y_n &= (I - A^{*3})^{-1}(I + A^* + A^{*2})(I - \tilde{A}_n)^{-1} x \\ &= M_{a3} M_{a2} M_{a1} x \\ &= M_a x \end{aligned} \tag{6}$$

or

$$\begin{aligned} y_n &= (I - A_n)^{-1} x = (I - A^{*3})^{-1}(I + A^* + A^{*2})(I - \tilde{A}_n)^{-1} x \\ &\Rightarrow M_a x = M_{a3} M_{a2} M_{a1} x \\ &\Rightarrow M_a = M_{a3} M_{a2} M_{a1} \end{aligned} \tag{7}$$

where

$$M_{a1} = \begin{bmatrix} I & 0 & 0 \\ 0 & (I - A_{22})^{-1} & 0 \\ 0 & 0 & (I - A_{33})^{-1} \end{bmatrix} \tag{8}$$

Following Stone (1985), the multiplier effects included in $\mathbf{M_{a1}}$ arise from the repercussions of the initial injection within the group of accounts (or subsystems) that it originally entered. This measures the “intra-group” effects.

$$A^* = \begin{bmatrix} 0 & A^*_{13} A^*_{32} & 0 \\ 0 & 0 & A^*_{21} A^*_{13} \\ A^*_{32} A^*_{21} & 0 & 0 \end{bmatrix} \tag{9}$$

so that

$$M_{a2} = \begin{bmatrix} I & A^*_{13} A^*_{32} & A^*_{13} \\ A^*_{21} & I & A^*_{21} A^*_{13} \\ A^*_{32} A^*_{21} & A^*_{32} & I \end{bmatrix} \tag{10}$$

The multiplier effects included in $\mathbf{M_{a2}}$ arise from the repercussions of the initial injection when it has completed a tour outside its original group without returning to it, and so may be said to measure the “inter-group” effects.

$$M_{a3} = \begin{bmatrix} (I - A^*_{13}A^*_{32}A^*_{21})^{-1} & 0 & 0 \\ 0 & (I - A^*_{21}A^*_{13}A^*_{32})^{-1} & 0 \\ 0 & 0 & (I - A^*_{32}A^*_{21}A^*_{13})^{-1} \end{bmatrix} \quad (11)$$

The multiplier effects included in matrix $\mathbf{M_{a3}}$ arise from the results/consequences of the initial injection (from an exogenous account) when it has completed a tour through all three groups (factors, institutions and production activities) and has returned to the one that it had originally entered, and so may be said to measure the "circular / closed loop" effects.

In order to improve household welfare or per capita food consumption as part of a country's food security strategy, accounting matrix multipliers such as $\mathbf{M_{a1}}$, $\mathbf{M_{A2}}$ and $\mathbf{M_{a3}}$ can assist in explaining the effects of an injection, from exogenous accounts, on expenditures of endogenous accounts. As there are no transfers between factors, because the $\mathbf{M_{a1}}$ comprises of a unit/identity matrix, it is therefore possible to measure the multiplier effects of inter-group/closed-loop and extra/open loops on endogenous accounts. The $\mathbf{M_{a3}}$ multiplier or circular matrix measures the repercussions of the initial injection following the complete tour through all three groups (factors, institutions and production activities) and returns to the group it originally entered.

For instance, the injection may originate with factors and proceed through institutions and production activities, back to factors. $\mathbf{M_{a3}}$ illustrates this circular/closed loop effect of the injection. If we inject income into the factor account first, this additional money income will be spent in the factor group through the institutional as well as the production account until it returns to the factor account group; and by so doing this constitutes a circular flow or closed loop. The income expended on each of the endogenous accounts is referred to as a leakage.

Depending on the income elasticity of the various goods and services that different income household groups purchase, generally it is expected that for low-income households an increase in disposable income (injection) will increase the food budget share, while for high-income household groups such an increase in income may lead to a reduction of the food budget share. This economic observation is consistent with Engel's law that, *ceteris paribus*, if real per capita incomes increase, the budget share of food expenditure generally declines and that this result is more pronounced among high-income families.

The inter-group/circular effects derived through the $\mathbf{M_{a3}}$ multiplier matrix analysis show how an injection of income affects the expenditures of the various households/ income groups. The higher-income group will expend proportionately more of their additional income on goods/services with higher income elasticities (transport, entertainment, clothing, etc), while low-income families spend more of their additional income on basic goods and services (food, etc.). From the food security perspective, an increase in disposable income through higher agricultural export earnings, or a reduction in per capita income taxes/import levies on food and the like, may improve household welfare/consumption but this will vary from one household income group to another. Those directly involved in export agricultural production may benefit more than those outside the sub-sector, as the Stopler-Samuelson theory indicates (see Chapter 3).

Whilst the closed/circular loop examines the effects of an injection of inter-group linkages through the $\mathbf{M_{a3}}$ multiplier matrix, repercussions also emanate from the extra or open loop relationships. The $\mathbf{M_{a2}}$ matrix captures an injection of income, say into the factor group, through institutions as well as activities, but the injection does not return to the factor group where it originally started. In general, the closed loop/inter-group effects stemming from $\mathbf{M_{a3}}$ are larger than those of extra/open loop effects, $\mathbf{M_{a2}}$**.** This means that the effects on endogenous expenditure accounts arising from $\mathbf{M_{a3}}$ (the closed/circular loop) are greater than those from extra/open loop relationships. In short, the leakage effect is higher in the circular/closed loop multiplier ($\mathbf{M_{a3}}$).

To facilitate a more useful and informative way to present SAM results stemming from decomposed matrix multiplier analysis, Stone (1985) suggested an additive form of the equation of the accounting multipliers (**M_{a1}, M_{a2}** and Ma3), as indicated below:

$$\mathbf{M = I + (M_{a1} - I) + (M_{a2} - I)\, M_{a1} + (M_{a3} - I)\, M_{a2}M_{a1}} \qquad (12)$$

where the elements of $\mathbf{M_a}$ represent (a) the initial injection, **I**; (b) the net contribution of transfer multiplier effects; (c) the net contribution of open-loop or extra group/cross multiplier effects; and (d) the net contribution of circular/inter-group or closed-loop multiplier effects.

5.4.2 Fixed-Price Multipliers

Whereas the accounting multipliers provide very useful information on the general structure of the economy, these multipliers cannot be interpreted directly as measures of the effects of changes in injections into the economy on the levels of endogenous incomes. For this latter purpose, we need to know how different economic agents behave in response to changes (Pyatt & Round, 1985, p.197).

In particular, it is important to analyze or measure how injections into endogenous accounts influence expenditure patterns, assuming that prices of goods and services are fixed and yet income is allowed to vary. Since prices are fixed, multipliers generated under such conditions are called fixed-price multipliers.

Using the accounting balance equation

$$\mathbf{Y_n = n \quad + x} \qquad (13)$$

which is basically a row/column total for endogenous and exogenous accounts (see Table 5.1), we can derive these equations if (13) is totally differentiated:

$$\partial \mathbf{y_n} = \partial \mathbf{n} + \partial \mathbf{x} \tag{14}$$

$$= \mathbf{C_n} \, \partial \mathbf{y_n} + \partial \mathbf{x} \tag{15}$$

$$= (\mathbf{I} - \mathbf{C_n})^{-1} \partial \mathbf{x} \tag{16}$$

$$= \mathbf{M_c} \, \partial \mathbf{x} \tag{17}$$

Similarly, the following equations can be derived, assuming $(\mathbf{I} - \mathbf{C_n})^{-1}$ exists.

$$\mathbf{dl} = \mathbf{C_l} \, \mathbf{dy_n} \tag{18}$$

$$= \mathbf{C_1} (\mathbf{I} - \mathbf{C_n})^{-1} \partial \mathbf{x} \tag{19}$$

$$= \mathbf{C_l} \, \mathbf{M_c} \, \mathbf{dx} \tag{20}$$

Assuming prices are fixed, the **n** vector of incomes received by endogenous accounts (factors, households/institutions and productive activities) is therefore a function of y_n and is constant.

The (i, j) element of the matrix C_n is the partial derivative of the element of n with respect to the element of y_n. C_n in this case is a matrix of the marginal propensity to consume.

Further, if $(\mathbf{I} - \mathbf{C_n})^{-1}$ exists, equation (17) shows how the elements of y_n change, following changes in injections from exogenous accounts. Similarly, the matrix C_1 in equation (18) is a matrix of marginal propensities to leak; hence equations (19) and (20). Equations (17) and (20) are similar to the preceding accounting multiplier equation:

$$\mathbf{y_n} = (\mathbf{I} - \mathbf{A_n})^{-1} \mathbf{x} = \mathbf{M_{ax}}$$

As a result of this similarity and assuming that C_n is non-negative, $\mathbf{M_c}$ in equation (20) is a multiplier matrix, referred to as a fixed-price multiplier matrix. Given matrices such as C_n and C_l whose column sums must add up to one/unity, the fixed-price multiplier matrix, $\mathbf{M_c}$ will also exist under conditions similar to the accounting multiplier matrix, $\mathbf{M_a}$. Consequently, given the estimates of matrices C_n and C_l, both the fixed-price multiplier, $\mathbf{M_c}$, and the matrix of marginal leakages, $\mathbf{C_l\, M_c}$, can be calculated.

Decomposition of the fixed-price multipliers

Like the accounting multiplier matrices, assuming that $\mathbf{C_n}$ and $\mathbf{A}_n$ are equal (and by extension that $\mathbf{C_l}$ and $\mathbf{A_l}$ are also equal), the fixed-price multiplier matrix can be decomposed into a transfer effects multiplier, $\mathbf{M_{c1}}$; an open-loop multiplier matrix, $\mathbf{M_{c2}}$; and a closed-loop multiplier matrix, $\mathbf{M_{c3}}$. Further, these multiplier effects can be expressed as a multiplicative product, as follows:

$$\mathbf{M_c = M_{c3}\, M_{c2}\, M_{c1}} \tag{21}$$

Alternatively, using the additive form developed by Stone, equation (21) can be re-written as

$$\mathbf{M_c = I + (M_{c1} - I) + (M_{c2} - I)\, Mc1 + (M_{c3} - I)\, Mc2\, M_{c1}} \tag{22}$$

Assuming prices are fixed, the differences that can be identified between the corresponding elements of the multipliers, $\mathbf{M_a}$, that is the accounting matrix, and $\mathbf{M_c}$, the fixed-price multiplier, are therefore due to income effects. This can be formally presented as follows:

$$\mathbf{dy_n = C_n\, dy_n + dx} \tag{23}$$

$$= \mathbf{(C_n - A_n)dy_n + A_n dy_n + dx} \tag{24}$$

$$= \mathbf{(I - A_n)^{-1}((C_n - A_n)\, dyn + dx)}$$

$$= \mathbf{M_a(C_n - A_n)dy_n + M_a\, dx}$$

$$= (\mathbf{I} - \mathbf{M_a}(\mathbf{C_n} - \mathbf{A_n}))^{-1}\, \mathbf{M_a dx}$$
$$= \mathbf{M_y M_a dx} \quad (25)$$

where $$\mathbf{M_y} = (\mathbf{I} - \mathbf{M_a}(\mathbf{C_n} - \mathbf{A_n}))^{-1} \quad (26)$$

and by definition $$\mathbf{M_y M_a} = \mathbf{M_c} \quad (27)$$

From equation (27) the matrix $\mathbf{M_y}$ captures the income effects and this matrix in turn transforms the accounting multiplier matrix, $\mathbf{M_a}$, into a fixed-price multiplier, $\mathbf{M_c}$.

5.5 Price Multiplier Analysis

Under fixed-price multiplier analysis income is allowed to vary while prices are held constant and this in turn makes input or commodity substitution extremely difficult, as there are no changes in relative prices. As Roland-Host and Sancho (1995) observe, "traditionally, the emphasis of the Social Accounting Matrix methodology has been on quantity-orientated models and their income effects. In contrast, we use the Social Accounting Matrix to develop a price model that captures the interdependence among activities, households, and factors and provides a complete set of accounting prices" (Roland-Holst and Sancho, 1995, p.361). The traditional use of SAM-based models here refers to fixed-price income multipliers, which this study will apply in Chapter 7 to examine the effects of an increase in export income on food security. For instance, case studies used later in this chapter illustrate results of the applications of SAM models based on the fixed-price income multiplier analysis. The fixed-price income multiplier analysis assumes that prices are not allowed to vary. As a result of this assumption, it is not possible for households to replace costly commodities with cheaper ones, while activities also cannot substitute less costly inputs for more expensive ones as there are no relative price changes.

In this study, some of the policy simulations/experiments will include tariff reduction among selected commodities, which in turn reduce domestic prices as well as production costs in the activity account. Chapter 8 will undertake policy experiments based on the effects of tariff reduction or price changes on food security and sectoral competitiveness. The SAM multiplier analysis that introduces price changes in a policy experiment, as opposed to the fixed-price income multiplier approach, is referred to as **price-multiplier analysis**. Further, under price multiplier analysis income as well as quantities of commodities are held constant. As a result a reduction of a tariff on an imported good, *ceteris paribus*, not only reduces its domestic price and influences relative prices, production costs of activities (via changes in inputs costs,) as well as changes in the cost of living are also affected. As Roland-Holst and Sancho (1995) indicate, tariff reduction shows how prices are formed as well as the transmission of cost among various endogenous accounts in the economy; hence the duality of price multiplier models.

Through tariff reduction/liberalization (see Chapter 8), policy experiments will analyze price formation as well as the cost of transmission among endogenous accounts, with special reference to the welfare of households and production costs of activities. The introduction of tariff reduction in selected commodities affects transactions in the quantities traded and relative prices /costs in the domestic economy. Further, according to the results of the price multiplier analysis undertaken by Roland-Holst and Sancho in Spain, endogenous accounts (factors, households and sectors/activities) respond differently to exogenous price changes/shocks (Roland-Holst and Sancho, 1995). In fact, similar findings have been observed in this study, as Chapter 8 will show. Below we outline steps taken to derive price multipliers.

Table 5.2 illustrates a schematic SAM like the one illustrated in table 5.1, in which transactions are recorded using both quantities and prices. Endogenous activities cover factors (1), households (2) and activities/production (3) while capital, government and the rest of the world are all together treated as one exogenous account (4) and the respective totals of transactions are captured by (5). Rows still represent income or receipts while columns indicate account expenditures.

Table 5.2: A schematic SAM

	1 2 3	4	5
Factors (1)	**0** **0** $\hat{p}_1\mathbf{Q}_{13}$	$\hat{p}_1{}'\mathbf{Q}_{14}$	$\hat{p}_1{}'\mathbf{q}_1$
Households (2)	$\hat{p}_2{}'\mathbf{Q}_{21}$ $\hat{p}_2{}'\mathbf{Q}_{22}$ **0**	$\hat{p}_2{}'\mathbf{Q}_{24}$	$\hat{p}_2{}'\mathbf{q}_2$
Production (3)	**0** $\hat{p}_3{}'\mathbf{Q}_{32}$ $\hat{p}_3{}'\mathbf{Q}_{33}$	$\hat{p}_3{}'\mathbf{Q}_{34}$ $\hat{p}_4{}'\mathbf{Q}_{44}$	$\hat{p}_3{}'\mathbf{q}_3$ $\hat{p}_4{}'\mathbf{q}_4$
Exogenous (4)	$\hat{p}_4{}'\mathbf{Q}_{41}$ $\hat{p}_4{}'\mathbf{Q}_{42}$ $\hat{p}_4{}'\mathbf{Q}_{43}$		
Totals	$\hat{p}_1{}'\mathbf{q}_1$ $\hat{p}_2{}'\mathbf{q}_2$ $\hat{p}_3{}'\mathbf{q}_3$	$\hat{p}_4{}'\mathbf{q}_4$	

Defining the technical coefficients as

$$a_{ij} = \frac{Q_{ij}}{q_j} \quad \textbf{or} \quad Q_{ij} = a_{ij}q_{ij} \qquad (1)$$

the transactions matrix can be rewritten as

	1 2 3	4	5
Factors (1)	$\mathbf{0}$ $\mathbf{0}$ $\hat{p}_1\mathbf{A}_{13}\hat{q}_3$	$\hat{p}_1'\mathbf{A}_{14}\hat{q}_4$	$\hat{p}_1'\mathbf{q}_1$
Households (2)	$\hat{p}_2'\mathbf{A}_{21}\hat{q}_1$ $\hat{p}_2'\mathbf{A}_{22}\hat{q}_2$ $\mathbf{0}$	$\hat{p}_2'\mathbf{A}_{24}\hat{q}_4$	$\hat{p}_2'\mathbf{q}_2$
Production (3)	$\mathbf{0}$ $\hat{p}_3'\mathbf{A}_{32}\hat{q}_2$ $\hat{p}_3'\mathbf{A}_{33}\hat{q}_3$	$\hat{p}_3'\mathbf{A}_{34}\hat{q}_4$	$\hat{p}_3'\mathbf{q}_3$
Exogenous (4)	$\hat{p}_4'\mathbf{A}_{41}\hat{q}_1$ $\hat{p}_4'\mathbf{A}_{42}\hat{q}_2$ $\hat{p}_4'\mathbf{A}_{43}\hat{q}_3$	$\hat{p}_4'\mathbf{A}_{44}\hat{q}_4$	$\hat{p}_4'\mathbf{q}_4$
Totals	$\hat{p}_1'\mathbf{q}_1$ $\hat{p}_2'\mathbf{q}_2$ $\hat{p}_3'\mathbf{q}_3$	$\hat{p}_4'\mathbf{q}_4$	

and dividing throughout by $\mathbf{q}_i$ as appropriate, i.e., by the columns, gives

	1	2	3	4	5
Factors (1)	**0** $\hat{p}_1\mathbf{A}_{13}$		**0**	$\hat{p}_1{}'\mathbf{A}_{14}$	$\hat{p}_1$
Households (2)	$\hat{p}_2{}'\mathbf{A}_{21}$	$\hat{p}_2{}'\mathbf{A}_{22}$	**0**	$\hat{p}_2{}'\mathbf{A}_{24}$	$\hat{p}_2$
Production (3)	**0** $\hat{p}_3{}'\mathbf{A}_{33}$		$\hat{p}_3{}'\mathbf{A}_{32}$	$\hat{p}_3{}'\mathbf{A}_{34}$	$\hat{p}_3$
Exogenous (4)	$\hat{p}_4{}'\mathbf{A}_{41}$	$\hat{p}_4{}'\mathbf{A}_{42}$	$\hat{p}_4{}'\mathbf{A}_{43}$	$\hat{p}_4{}'\mathbf{A}_{44}$	$\hat{p}_4$
Totals	$\hat{p}_1{}'$	$\hat{p}_2{}'$	$\hat{p}_3{}'$	$\hat{p}_4{}'$	

The resultant column identities are then

$$\mathbf{p}_1 = \mathbf{p}'_2\mathbf{A}_{21} + \mathbf{p}'_4\mathbf{A}_{41}$$

$$\mathbf{p}_2 = \mathbf{p}'_2\mathbf{A}_{22} + \mathbf{p}'_3\mathbf{A}_{32} + \mathbf{p}'_4\mathbf{A}_{42} \qquad (2)$$

$$\mathbf{p}_3 = \mathbf{p}'_1\mathbf{A}_{13} + \mathbf{p}'_3\mathbf{A}_{33} + \mathbf{p}'_4\mathbf{A}_{43}$$

$$\mathbf{p}_4 = \mathbf{p}'_1\mathbf{A}_{14} + \mathbf{p}'_2\mathbf{A}_{24} + \mathbf{p}'_3\mathbf{A}_{34} + \mathbf{p}'_4\mathbf{A}_{44}$$

Letting the matrices A_{4i} for **I** =1, 2, 3, be row vectors and p_4 be a scalar, i.e., a "weighted" average price, the vector of exogenous costs, v, is

$$V = p_4 \mathbf{a}_4 \tag{3}$$

where a_4 is formed from the row adjoining the matrices $\mathbf{A}_{4i,}$ i.e., $\mathbf{a}_{4} = i' [\mathbf{A}_{41}, \mathbf{A}_{42}, \mathbf{A}_{43}, \mathbf{A}_{44}]$.

Further defining

$$\mathbf{p} = (\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3) \tag{4}$$

the price dual can be written as

$$\begin{aligned} \mathbf{p}' &= \mathbf{p}'\mathbf{A} + \mathbf{V}' \\ &= \mathbf{v}'[\mathbf{I} - \mathbf{A}_n]^{-1} \\ &= \mathbf{v}'\mathbf{M}_p \\ &= \mathbf{M}_p'\mathbf{v} \end{aligned} \tag{5}$$

where

$$\mathbf{A} = \begin{bmatrix} 0 & 0 & A_{13} \\ A_{21} & A_{22} & 0 \\ 0 & A_{32} & A_{33} \end{bmatrix} \tag{6}$$

Whilst in terms of the fixed-price income multiplier analysis the interpretation of the multiplier matrix is undertaken through the rows of $\mathbf{M_p}$, an exogenous change in the price or cost experienced by an endogenous account or activity is transmitted in the economy by the row elements of the Multiplier Matrix. Similarly, the effects of an exogenous increase in the price faced by an account are transmitted by the row elements of $\mathbf{M_p}$. In Chapter 8 of this study, a price multiplier analysis, based on the reduction of tariffs will be undertaken.

Price Multiplier Decomposition

As with the fixed-price income multiplier derived by Pyatt and Round and Stone, a decomposed price multiplier can also be created. Using the price dual expression, then for any matrix, **Ã,** which is conformable with **A,** we can write

$p' = p'A + v' \quad = p'A + p'\tilde{A} - p'\tilde{A} + v'$

$p' - p'\tilde{A} = p'\tilde{A} - p'\tilde{A} + v'$ (7)

$p'(I - \tilde{A}) = p'[A - \tilde{A}] + v'$

$p' = p'[A - \tilde{A}](I - \tilde{A})^{-1} + v'(I - \tilde{A})^{-1}$

and letting $A^{*} = [A - \tilde{A}][I - \tilde{A}]^{-1}$

$p' = p'A^{*} + v'(I - \tilde{A})^{-1}$ (8)

and multiplying throughout by A*

$p'A^{*} = (p'A^{*} + v'(I - \tilde{A})^{-1})A^{*}$ (9)

and noting that

$p'A^{*} = p' - v'(I - \tilde{A})^{-1}$ (10)

then

$p' - v'(I - \tilde{A})^{-1} = (p'A^{*} + v'(I - \tilde{A})^{-1})A^{*}$

$p' = (p'A^{*} + v'(I - \tilde{A})^{-1})A^{*} + v'(I - \tilde{A})^{-1}$ (11)

$= p'A^{*2} + v'(I - \tilde{A})^{-1}A^{*} + v'(I - \tilde{A})^{-1}$

$= p'A^{*2} + v'(I - \tilde{A})^{-1}(I + A^{*})$

using $p' = p'A^{*} + v'(I - \tilde{A})^{-1}$ to substitute for p' on the right hand side we have

$p' = (p'A^{*} + v'(I - \tilde{A})^{-1})A^{*2} + v'(I - \tilde{A})^{-1}(I - A^{*})$

$= p'A^{*3} + v'(I - \tilde{A})^{-1}A^{*2} + v'(I - \tilde{A})^{-1}(I + A^{*})$ (12)

$= p'A^{*3} + v'(I - \tilde{A})^{-1}(A^{*3} + (I + A))$

$= p'A^{*3} + v'(I - \tilde{A})^{-1}(I + A^{*} + A^{*2})$

and solving for p'

$p' = p'A^{*3} + v'(I - \tilde{A})^{-1}(I + A^{*} + A^{*2})$

$p' - p'A^{*3} = v'(I - \tilde{A})^{-1}(I + A^{*} + A^{*2})$

$p'(I - A^{*3}) = v'(I - \tilde{A})^{-1}(I + A^{*} + A^{*2})$ (13)

$p' = v'(I - \tilde{A})^{-1}(I + A^{*} + A^{*2})(I - A^{*3})$

$= v'M_{P1}M_{P2}M_{P3}$

where

$\mathbf{M}_{p1} = (\ \mathbf{I} - \tilde{\mathbf{A}}\ )^{-1}$ (14)

$\mathbf{M}_{p2} = (\mathbf{I} + \mathbf{A}^* + \mathbf{A}^{*2}\ )$

$\mathbf{M}_{p3} = (\ \mathbf{I} - \mathbf{A}^{*\ 3}\ )$

Defining the matrix Ã as

$$\tilde{\mathbf{A}} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & A_{22} & 0 \\ 0 & 0 & A_{33} \end{bmatrix} \tag{15}$$

then[4]

$$\left[I - \tilde{A}\right]^{-1} = \begin{bmatrix} I & 0 & 0 \\ 0 & [I - A_{22}]^{-1} & 0 \\ 0 & 0 & [I - A_{33}]^{-1} \end{bmatrix} \tag{16}$$

and $\left(A - \tilde{A}\right)$ is

$$\left(A - \tilde{A}\right) = \begin{bmatrix} 0 & 0 & A_{13} \\ A_{21} & 0 & 0 \\ 0 & A_{32} & 0 \end{bmatrix} \tag{17}$$

thus

$$\mathbf{A}^* = \begin{bmatrix} 0 & 0 & A_{13}[I - A_{33}]^{-1} \\ A_{21} & 0 & 0 \\ 0 & A_{32}[I - A_{22}]^{-1} & 0 \end{bmatrix}$$

$$\mathrm{A}^{*2} = \begin{bmatrix} 0 & A_{13}[I - A_{33}]^{-1} A_{32}[I - A_{22}]^{-1} & 0 \\ 0 & 0 & A_{21}A_{13}[I - A_{33}]^{-1} \\ A_{32}[I - A_{22}]^{-1} A_{21} & 0 & 0 \end{bmatrix}$$

$\mathbf{A}^{*3} =$

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[4] Note that the inverse of a block diagonal matrix **A** is

$$\mathrm{A}^{-1} = \begin{bmatrix} A_{11}^{-1} & 0 \\ 0 & A_{22}^{-1} \end{bmatrix} \quad \text{where} \quad \mathrm{A} = \begin{bmatrix} A_{11} & 0 \\ 0 & A_{22} \end{bmatrix}$$

$$\begin{bmatrix} A_{13}[I-A_{33}]^{-1}A_{32}[I-A_{22}]^{-1}A_{21} & 0 & 0 \\ 0 & A_{21}A_{13}[I-A_{33}]^{-1}A_{32}[I-A_{22}]^{-1} & 0 \\ 0 & 0 & A_{32}[I-A_{22}]^{-1}A_{21}A_{13}[I-A_{33}]^{-1} \end{bmatrix}$$

(18)

Defining

$$\mathbf{A}^*_{13} = \mathbf{A}_{13}\,(\mathbf{I} - \mathbf{A}_{33})^{-1}$$

$$\mathbf{A}^*_{21} = \mathbf{A}_{21} \qquad (19)$$

$$\mathbf{A}^*_{32} = \mathbf{A}_{32}\ (\mathbf{I} - \mathrm{A}_{22})^{-1}$$

the expressions for $\mathbf{A}^*$, $\mathbf{A}^{*2}$ and $\mathbf{A}^{*3}$ can be written as

$$\mathbf{A}^* = \begin{bmatrix} 0 & 0 & A^*_{13} \\ A^*_{21} & 0 & 0 \\ 0 & A^*_{32} & 0 \end{bmatrix}$$

$$\mathbf{A}^{*2} = \begin{bmatrix} 0 & A^*_{13}A^*_{32} & 0 \\ 0 & 0 & A^*_{21}A^*_{13} \\ A^*_{32}A^*_{21} & 0 & 0 \end{bmatrix} \qquad (20)$$

$$\mathbf{A}^{*3} = \begin{bmatrix} A^*_{13}A^*_{32}A^*_{21} & 0 & 0 \\ 0 & A^*_{21}A^*_{13}A^*_{32} & 0 \\ 0 & 0 & A^*_{32}A^*_{21}A^*_{13} \end{bmatrix}$$

Therefore

$$\mathbf{M}_{p1} = \left[I - \tilde{A}\right]^{-1} = \begin{bmatrix} I & 0 & 0 \\ 0 & \left[I - A_{22}\right]^{-1} & 0 \\ 0 & 0 & \left[I - A_{33}\right]^{-1} \end{bmatrix} \qquad (21a)$$

$$\mathbf{M}_{p2} = \left(I + A^* + A^{*2}\right) = \begin{bmatrix} I & A_{13}^* A_{32}^* & A_{13}^* \\ A_{21}^* & I & A_{21}^* A_{13}^* \\ A_{32}^* A_{21}^* & A_{32}^* & I \end{bmatrix} \qquad (21b)$$

$$\mathbf{M}_{p3} = \left[I - A^{*3}\right]^{-1} = \begin{bmatrix} \left[I - A_{13}^* A_{32}^* A_{21}^*\right]^{-1} & 0 & 0 \\ 0 & \left[I - A_{21}^* A_{13}^* A_{32}^*\right]^{-1} & 0 \\ 0 & 0 & \left[I - A_{32}^* A_{21}^* A_{13}^*\right]^{-1} \end{bmatrix} \qquad (21c)$$

Source: Roland-Holst and Sancho, 1995

The multipliers $\mathbf{M}_{p1}$, $\mathbf{M}_{p2}$ and $\mathbf{M}_{p3}$ capture, as in accounting/income multiplier analysis, transfer (T_p), open- (O_p) and closed-loop (C_p) effects respectively. Chapter 8 will use these disaggregated price multipliers to explain the effects of exogenous shocks on endogenous accounts and subsequently on food security and activity accounts.

Additive Decomposition of Multiplier

As was the case in income multiplier analysis, an additive decomposition of the multiplicative multiplier by Pyatt and Round (1979) can also be done under price multiplier analysis. By means of Stone's additive decomposition of the multiplicative multiplier we can derive,

$$\mathbf{M}_p = \mathbf{I} + (\mathbf{M}_{P1} - \mathbf{I}) + \mathbf{M}_{P1}(\mathbf{M}_{P2} - \mathbf{I}) + \mathbf{M}_{P1}\mathbf{M}_{P2}(\mathbf{M}_{P3} - \mathbf{I})$$
$$= \mathbf{I} + \mathbf{T}_P + \mathbf{O}_P + \mathbf{C}_P.$$

The interpretation of the additive and decomposed price multiplier, M_p, is the same as in accounting/income multiplier analysis. Chapter 8 will also use Stone's additive and decomposed multiplier analysis. The importance of the use of decomposed multipliers is to provide information especially to policy makers about "the underlying patterns of economic interdependence and price transmission" (Roland-Holst and Sancho, 1995, p.370). In particular, such information can reveal whether there is competition and full transmission of the cost/tariff reduction in the economy following the introduction of a shock into the endogenous accounts. Rigity in the input and output markets after price changes, say through tariff reduction, can be a policy challenge during trade liberalization (Stiglitz, 1998; 2002).

5.6 Empirical Evidence Regarding Trade Liberalization using SAM-based Models

Following the global trend towards trade liberalization, several models have been applied to assess the effects of the removal of tariffs and other non-tariff barriers (NTBs) on the economies of various countries. In Chapter 4, we described the empirical experience of partial equilibrium analysis in trade liberalization.

Firstly, Powell and Round (1997) undertook a SAM income multiplier analysis of Ghana. The policy experiment was based on the effects of additional export income of cocoa on the economy. Cocoa is a very important agricultural export commodity for Ghana. Government, capital and the rest of the world were treated as exogenous accounts while factors, households and activities were endogenous accounts in a static SAM income multiplier analysis. The study established that unskilled male workers and mixed income were the largest beneficiaries of additional export income stemming from an increase in global demand for cocoa. Unskilled male workers form the backbone of factor employment in primary cocoa production in Ghana, while mixed income represents returns to labour for non-incorporated firms.

Besides returns to labour, certain urban and rural households also benefited significantly from an increase in international cocoa demand (Powell and Round, 1997). These households own factors such as labour. Among activities, primary cocoa production was the largest recipient of export income from cocoa, as its output increased greatly. The study also found that compared to a similar income injection in mining and construction, an increase in income from cocoa exports exhibited a comparable national impact to that of construction while such an increase in the effect of the income from mining was less. In short, an injection of additional export income into cocoa produces similar effects or national benefits to the construction industry. However, the study found that system-wide linkages or closed-loop effects (see detailed discussion in Chapters 7 and 8) were weak in the Ghanaian economy, demonstrating limited interdependency or income interrelationships among endogenous accounts.

Secondly, in a study on macro-economic, trade and agricultural reforms in Zimbabwe, Bautista and Thomas (2000), using a SAM-income multiplier analysis, found that not only does the GDP increase, but also that foreign trade and household income distribution improved significantly. Resource allocation based upon the Ricardian/HOS model also improved. Trade creation dominated trade diversion and smallholder farm production also increased because of improved access to land and competitive world commodity prices following the removal of price and exchange rate controls. As one would expect, Zimbabwe, like several other low-income countries, depends on trade tariff revenue. Consequently, while economic and trade reforms benefit the macro-economy in the form of higher GDP and also increase household income, government revenue is adversely affected. Loss of government revenue can reduce expenditure on providing public goods such as infrastructure, health, education and research. For a developing country like Zimbabwe, the failure to provide public goods could be politically and socially very costly.

While the Zimbabwe study (2000) advocates for major fiscal and monetary reforms including trade liberalization, the investigation also supports a comprehensive land reform for the benefit of smallholders but advises against a disruptive land distribution that destroys production and employment among large-scale farmers. The study supports the distribution of unused land and implementation of other complementary policies in infrastructure, education, water, input supply, etc.

Regarding economic and trade reforms, however, the same study identifies serious crises. Zimbabwe has over the years regulated trade by means of price and exchange rate controls, quotas, import duties, monopoly controls, and the like. The currency is overvalued while inflation, interest and unemployment rates are very high. Moreover, government over-expenditure has created chronic budget deficits. The macro-economic reforms advocated in the study mentioned, apart from trade and agricultural liberalization, also cover financial discipline. The recent government programme of economic revival attempts to implement the reforms indicated in the study, as well as to expand the role of the private sector in trade (2003). Recently, however, government has been gradually relaxing controls on the economy.

In another SAM income multiplier analysis of Mozambique, Arndt, Jensen and Tarp (2000) established that primary agriculture displays strong income linkages in the country's economy. According to this study, primary agriculture accounts for about 28 percent of Mozambique's GDP while services, industry and commerce also account for 27 percent, 25 percent and 20 percent, respectively, of the country's GDP. Factors, households and activities were classified as endogenous accounts while, as is the general convention, government, capital and the rest of the world were treated as exogenous accounts.

The results of the study on Mozambique indicate that primary agriculture exhibited the largest income multipliers on factor account, compared to industry and services. Specifically, a unit increase in income from agriculture generated the greatest demand for factors (labour and capital), compared to industry and services. As was to be expected, agricultural labour gained most from primary agriculture while non-agricultural labour benefited most from the demand created by the services sector. Further, following an injection of additional income into activities, primary agriculture and the services sector exhibited a comparable demand for capital while industry lagged behind (Arndt, Jensen and Tarp, 2000).

Rural households improved their welfare after an injection of additional income into primary agriculture, while urban households registered almost the same benefits in both the agriculture and the services sectors. Industry lagged behind for both types of households. Rural households gained most in terms of additional income injected into agriculture, followed by the services industry, while urban households benefited almost equally in both the agriculture and services sectors. Like most SADC countries, Mozambique's population is largely rural and depends mainly on farming and therefore, the development and support of this sector could create more broadly-based benefits to the economy.

With respect to the activity account, the results of the Mozambique study indicate that an injection of additional income into agriculture exerts an almost similar effect on total sectoral output to that on the services sector. Through inter-industry input-output interactions, an injection of additional income into agriculture generates almost the same sectoral output as the services sector, while industry exhibits limited inter-industry or transfer effects. The most important agricultural activities that demonstrated the highest production linkages in Mozambique were rice, other grains, raw cashew, raw cotton, forestry, livestock and fishery production. Some of these activities provide Mozambique with important export commodities. The same primary agricultural activities also created the largest demand for factors including agricultural labour (Arndt, Jensen and Tarp, 2000).

The experiences and lessons on economy-wide analysis indicated in the preceding paragraphs are based on SAM multiplier analysis, the tool which study will mainly focus on in Chapters 7 and 8. In addition, to experiences based on SAM multiplier analysis, other economy-wide studies on agricultural trade liberalization and food security using computable general equilibrium (CGE) investigations have been made. CGE analysis while based on a SAM database like SAM multiplier analysis, it has different features. In CGE analysis, an advanced and more complex economy-wide approach, all accounts are endogenous, whilst under SAM multiplier analysis, factors, households and activities are classified as endogenous while government, capital and the rest of the world are conventionally treated as exogenous (see Chapters 7 and 8 about how accounts were classified in this study). Secondly, in CGE studies, bilateral trade flows are covered whereas in SAM multiplier analysis, they are not included. Thirdly, in CGE analysis it is assumed foreign goods are not perfect substitutes of domestically produced goods, e.g. white maize in Botswana/SACU is not perfectly substituted for by white maize from Europe or the United States. There are other distinguishing features between the two economy-wide tools.

However, there are equally important common features between the two approaches that are based on the SAM database. Both analytical tools reveal the interdependence of accounts through the circular flow of income and expenditure. Secondly, the disaggregation of the multiplier effects can provide useful information about the behaviour of markets through the strength/weakness of price transmission when a shock is applied. The general direction of multiplier effects on factors, households and activities is generally the same between the two analytical tools. Below are some of the lessons/experiences on agricultural trade liberalization based on CGE approach which show some common features with SAM multiplier analysis.

Weck and Piermartini (2005) in their CGE study on the economic impact of the economic partnership agreements(EPAs) in SADC countries, found that livestock and food sectors would benefit more if the region entered into a free trade area with the European Union(EU). The EU and African, Caribbean and Pacific (ACP) countries are currently negotiating for the creation of regional free trade areas or EPAs in order to establish reciprocal trade and strengthen regional economic and trade integration, etc. Currently, the EU has non-reciprocal arrangements with ACP countries except for South Africa as the latter is classified as a developed country. To achieve the EPA objective, ACP countries are expected to form geographic economic groups to establish free trade areas. SADC is currently negotiating an EPA with the EU.[5] According to the study, SADC should strongly advocate for the inclusion of agricultural products in the EPA negotiations as they enjoy comparative advantage in them vis-à-vis the EU. The EU has comparative advantage in manufactures. In a highly aggregated CGE analysis, where there were no households, etc, Weck and Piermartini found that overall, the welfare of SADC improved as well as the region's GDP. The study also indicated that if the EPA is established trade diversion could occur as cheaper imports from other parts of the world could be replaced by expensive ones from the EU. Inflows of costly and uncompetitive food and agricultural imports from the EU in particular, could adversely affect household food security and per capita food consumption.

Bouet (2006) in a CGE study on how trade liberalization can affect the poor, the researcher found that welfare gains globally increase mainly due to the reduction/removal of agricultural trade distortions, especially if the barriers are tariff-based. GDP in countries/regions covered increases due to efficiency gains. According to the study, agricultural tariffs constitute a major market access constraint in global trade. Whilst the agricultural sector was disaggregated, households were not included and factors were also not comprehensively disaggregated. Countries were also aggregated into regions with Africa represented by less than five countries. The results indicate that poverty will reduce through increase in income for unskilled workers engaged in agriculture. At household level, the results do not indicate specifically which ones would benefit between those in the rural and urban areas, or those who are self-employed vis-à-vis wage-based families, etc. The importance of non-tariff barriers in influencing potential gains is not captured in this study. Jean and Matthews (2005) identify non-tariff barriers such as sanitary and phyto-sanitary standards as critical for developing countries to access export markets. According to their study, tariff restrictions play a smaller role

[5] Some SADC members are however negotiating an EPA under the east and southern Africa configuration. Angola, Botswana, Lesotho, Namibia, Mozambique, Swaziland and Tanzania are negotiating under SADC.

compared to non-tariff barriers as currently developing countries enjoy duty-free or low-duty market access in several preferential trade arrangements.

Several economy-wide studies on trade liberalization and agricultural reforms also confirm that, in general, welfare will improve but that the gains are not equally distributed between the industrialized and low-income countries (Davies, Masters and Hertel, 1999; Trueblood and Shapouri, 1999; Wobst, 2002; Winters, McCulloch and McKay, 2004; FAO, 2005; Olympio, Robinson and Cocks, 2006; Bouet, 2006; Bouet and Krasniqi, 2006). In general, rural households as well as unskilled workers benefit most from income injected into primary agriculture, rather than into industry or manufacturing. As most of the poorest households in several developing countries including the SADC region are situated in rural areas and depend on farming, forestry and fisheries, the results of the case studies strongly favour investment in and support for agricultural development coupled with the implementation on complementary policies (infrastructure, skills development, education, water, etc.).

Furthermore, it is also necessary that, in order for global trade liberalization to benefit low-income or developing countries, in particular, major reforms be undertaken in the agricultural sector and other areas of the domestic and world economy. Results of studies on trade liberalization indicate that highly industrialized countries such as OECD members benefit most, as well as Australia, New Zealand and some middle-income Asian countries (Vaitinen, 2001; Brown, 2002). In addition, those countries with comparative cost advantage in agricultural exports (cereals, dairy, sugar, meat, fruits, vegetables, oilseeds and so forth) will benefit more from global trade liberalization, but net food-importing countries in the short term will be adversely affected by an increase in commodity prices if major trade players like the EU, US, and Japan reduce both export and domestic subsidies in conformity with their WTO obligations.

Trade liberalization will also assist in aligning interest and exchange rates with market forces. At present, several countries are adjusting these rates, partly owing to macroeconomic imbalances caused by, *inter alia*, overvalued currencies, subsidized interest rates, and chronic budget deficits. Several other studies concur with most of the findings or simulated results of these models. Specifically, trade liberalization, accompanied by other reforms such as aligning domestic exchange rates with international currencies, removal or reduction of barriers to trade (high import tariffs, quotas, export subsidies, import taxes, market/commodity monopolies, and the like) and macro-economic stability can contribute to economic growth, employment creation, household welfare, an increase in private investment and reduced public deficit.

5.7 Advantages and Disadvantages of SAM-Income Multiplier analysis

Economy-wide models provide information about structure and income distribution in an economy. Unlike the partial equilibrium models described in Chapter 4, SAM multiplier analysis also indicate inter- and intra-sectoral linkages by identifying income and expenditure interrelationships. For economies dependent on agricultural growth, an economy-wide model captures the links between factors (labour, capital) and households (rural or urban as well as poor or rich) to productive activities/services, government, capital and transactions with the rest of the world. Chapter 6 describes these inter-relationships in detail using the Botswana SAM. In fact as Reimer (2002, p.15) observes, SAM-based models "quantify at a single point in time, the interdependence of sectors and regions in an economy". Partial equilibrium models are not able to show such linkages.

While SAM multiplier analysis provides detailed information about economic linkages, income distribution, etc, there are indeed formidable problems facing them. Firstly, in many cases certain accounts such as factors and households might be too aggregated to understand any relationships. For instance, several economy-wide models using the Global Trade Analysis Project

(GTAP)[6] have for some time assumed one type of household in both country and regional analysis. As expected households are very different by area: rural versus urban. Further, households differ by income levels and sources of income. Some households depend on wages and self-employment while others subsist on transfers and remittances. The use of one household type in economy-wide models can be very misleading in policy designs or responses.

Further, economy-wide models are data and skill-intensive. Data are required from national accounts, household and income surveys as well as farm or agricultural surveys. In many countries these data may not be available at the same time in order for one to conduct a SAM-based analysis. In fact this data constraint may accord partial equilibrium analysis an advantage over economy-wide models. Fairly advanced analytical skills are required to undertake economy-wide investigations. In addition, many people may not easily understand and interpret economy-wide models.

5.8 Summary

This chapter described the SAM theory, income and price multipliers, and the advantages and disadvantages of economy-wide or SAM multiplier analysis. As sectors are directly and indirectly linked to one another and issues of efficiency, welfare and income re-distribution are becoming central in national, regional and global discussions and trade negotiations, economy-wide approaches will increasingly become more important, in measuring the full impact of various macro-economic reforms that partial equilibrium approaches are not able to capture more comprehensively. These factors include monetary, fiscal and trade reforms. However, both the economy-wide and partial equilibrium models should be regarded as complementary, given the advantages and disadvantages of each approach (Schiller, 1997; Gardner, 1998).

[6] GTAP is based at the University of Purdue, USA.