# SAM-Based Accounting Modeling and Analysis

# Sudan 2000

By

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## Abstract

SAM-based accounting multiplier is one of the tools used for policy decision making. It is consistent and comprehensive in nature in capturing wide arrays of economic activities of a country and sectoral linkages. The aim of this paper is to examine the nature of the multiplier effects of an income injection in the total outputs of the different production activities and households' income on Sudan economy using Sudan SAM for year 2000.

The model results reveal that injection of income (one SD[5] Billion) in any account benefits the account itself more, with service sector recording the highest response, followed by agriculture and industry . It also shows that the injection in agricultural sector yields the highest multipliers effect in GDP and household income, with the industrial sector attains the highest output multiplier effect. It is

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5. SD denotes Sudanese Diner, with one US$ = 257.1 SD in the year 2000. The Sudanese currency has been changed to Sudanese Geneh (SDG), which is one digit less than SD i.e ten SD in 2000 equal one SDG now

also clear that GDP multiplier is lower than output multiplier for all injections mainly due to taxes leakages. The results also indicate that households are better off if the injection takes place in the agricultural sector. This indicates the comparative advantage of the agricultural sector in playing a leading role in poverty mitigation as many are either employed or driving their livelihood entirely from this sector.

## 1. Background

The organization of the production sector, the characteristics of final demand, and the compensation of factors of production from value added, the ownership of factors by institutions and the system of transfers between institutions are all structural features of a functioning economic system; they also determine the distribution of income to individuals and household groups. Moreover, most of the policy interventions, especially in the developing countries, have been devoted to enhance growth, thus influencing variables at the aggregate and at the sectoral level. A framework at macro and meso levels is required to analyze the link between structural characteristic of the economic system and distribution of income as well as evaluating the impact on inequality of policy reforms. This comprehensive framework is represented by a Social Accounting Matrix (SAM).

The SAM has been developed for and used by developing countries more than developed economies in economic planning, given the greater prevalence of activist and centrally driven economic development policies in these countries (Pyatt and Round, 1985). A SAM depicts the entire circular flow of income for an economy in a square matrix format. It shows production leading to the generation of incomes which, in turn, are allocated to institutional sectors. In addition, it shows the redistribution of income leading to disposable income of institutional sectors. These incomes are either spent on products or saved. Expenditures by institutional sectors lead to production by domestic industries as well as supply from imports.

In the SAM, each cell in the matrix represents, by convention, a flow of funds from a column account to a row account. Rows track receipts, while columns track expenditures. Hence, row and column sums represent respectively total receipts and total payments by a given account. In the tradition of double entry accounting, row sums must equal column sums. A SAM can be estimated and presented for any level and type of aggregation which analyzes demands, provided data sources permit.

The aim of the paper is to examine the nature of the multiplier effects of an income injection in the total outputs of the different production activities and households' income on Sudan economy. The SAM used in this paper is an aggregated version of Sudan SAM for year 2000 developed by Elbushra (2007).

## 2. A Brief Description of Sudan SAM for Year 2000

The structure of Sudan SAM for year 2000 is presented in Table (1). It consists of six types of accounts, namely activities, commodities, factor of production, domestic institutions and rest of the world accounts. The activity (the entities that carry out production) and commodity (representing markets for goods and non-factor services) accounts are disaggregated into agriculture, industry and services accounts. The factor of production account is disaggregated into labor and capital accounts, where the domestic institutions account is disaggregated into households and government accounts.

The activities accounts row-wise, generate their income from selling goods and services to the commodity market. Column- wise they spend their income in payment to activities (intermediate demand), to factor of production (value added) and to the government (indirect taxes).

The commodities accounts receive income (row-wise), from intermediate demand and final demand. The final demand is composed of households' consumption of goods and services, government consumption, exports and investment goods. This row-wise income should be equal to aggregate demand (column-wise) supplied by activities in the form of marketed production in market price (including indirect taxes) and from the rest of world in the form of imports.

The factor of production account receives return from the production activities (row-wise) in form of value added as mentioned earlier and distributes it (column-wise) to household, government and to the rest of the world.

Households receive income from factors payments and transfer from the government. Income is allocated (column-wise) to consumption, income taxes and household savings.

The government account receipts include government share in returns to capital from production, direct taxes from households and indirect taxes from activities and commodities. The column of the government account provides the government expenditure in form of transfers to households, government final consumption and savings.

The capital account shows the balance of total investment (column-wise) and total savings from households, government and foreign savings (row- wise).

The rest of world account depicts the balance between foreign exchange outflow and inflow of a country. The row indicates the country outflows in form of imports and net factor income paid to households' transfers. The column indicates the inflows in form of exports and net capital inflows.

## Table 1: Macroeconomic SAM of Sudan Economy for Year 2000(SD Billion)

| | | Activities | | | Commodities | | | Factor of production | | Institutions | | Capital | Rest of the world | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | agric | ind. | serv. | agric. | ind. | serv. | lab | cap | hh | gov | | | |
| Activities | agric | | | | 1524.4 | | | | | | | | | 1524.4 |
| | ind. | | | | | 1060.9 | | | | | | | | 1060.9 |
| | serv. | | | | | | 2417.6 | | | | | | | 2417.6 |
| Commodities | agric | 132.6 | 259.2 | 309.2 | | | | | | 872.9 | 11.6 | 37.3 | 91.1 | 1713.9 |
| | ind. | 16.9 | 131.6 | 138.6 | | | | | | 456.1 | 1.5 | 57.1 | 357.0 | 1158.9 |
| | serv. | 171.3 | 193.8 | 315.0 | | | | | | 1611.5 | 171.5 | 294.3 | 42.2 | 2799.6 |
| Factor of production | lab | 218.7 | 131.7 | 557.3 | | | | | | | | | | 907.8 |
| | cap | 979.5 | 310.1 | 1086.0 | | | | | | | | | | 2375.6 |
| Institutions | hh | | | | | | | 907.4 | 2221.8 | | 32.8 | | | 3162.0 |
| | gov | 5.2 | 34.5 | 11.4 | 16.8 | 10.6 | 50.2 | | 153.8 | 39.1 | | | | 321.6 |
| Capital | | | | | | | | | | 95.3 | 104.3 | | 189.2 | 388.8 |
| Rest of the world | | | | | 172.7 | 87.5 | 331.8 | 0.4 | | 87.2 | | | | 679.5 |
| Total | | 1524.4 | 1060.9 | 2417.6 | 1713.9 | 1158.9 | 2799.6 | 907.8 | 2375.6 | 3162.0 | 321.6 | 388.8 | 679.5 | |

**Source: Recalculated from Elbushra (2007)**

**SAM-based multiplier model**

Analytically, a SAM can be considered as an extension of the traditional input-output framework. This format, in fact, adds some matrices, not included in the Leontief schema, which allow taking into account the relationships between factorial distribution of income, income distribution to Institutions and final demand. The inclusion in the SAM of data related to the production side and to income distribution and consumption expenditures, which depends on households behavior, allows also considering the SAM not only as a database and as an accounting tool, but also, in a wider sense, as a macroeconomic model (Civardi *et al*, 2008).

SAM multiplier models have been used for a wide range of issues from trade policies and macroeconomic shocks to farm-nonfarm linkages (see Pyatt and Round, 1985; Haggblade and Hazell, 1989; Reinert and Roland-Holst, 1997; Bautista, 2001; Diao *et al*. 2007).

Input-output multipliers capture only the inter-industry effects; even though these will propagate some income effects in so far as changes in outputs directly and indirectly affect incomes. However, under certain assumptions, the SAM multiplier would be focusing on determining the total effects that arise from an exogenous shock (changes in export demand, government spending, or investment demand). The total effect (multiplier effect) of these shocks is composed of direct and indirect effects. Direct effects are those pertaining to the sector that is directly affected by the shock, whereas the indirect ones are associated with linkages to other sectors and parts of the economy. These indirect linkages can, in turn, be separated into production and consumption linkages.

Production linkages are determined by sectors' production technologies and they are differentiated into backward and forward linkages. The backward production linkages are the demand for additional inputs used by producers to supply additional goods or services, while the forward production linkages account for the increase supply of inputs to upstream industries. On the other hand consumption linkages, arise when an expansion of production generates additional incomes for factors and households, which are then used to purchase goods and services (Breisinger *et al*, 2009).

SAM-based modeling requires that accounts be separated into endogenous and exogenous accounts. The need for this distinction arises from the fact that there must be an array into the system i.e. some variables must be multiplied exogenously via injections in order to evaluate the effects (Alarcon, 2000).

Therefore, in developing a simple multiplier model, the first step is to decide which accounts should be exogenous and which are to be endogenous. In this study, transaction in the government account, the capital account and the rest of the world account are regarded as exogenous. This is because government outlays are essentially determined by policy, the external sector is outside domestic control, and investment is exogenously-determined as the model has no dynamic features. Thus the endogenous accounts are therefore limited to those of activities, commodities, factors of production and households (private institutions). Defining the endogenous transactions in this way helps to focus on the interaction between two sets of agents (production activities and households) interacting through two sets of markets; factors and commodities (Round, 2003).

The model assumes that there is excess capacity that would allow relative prices to remain constant in the face of demand shocks; that expenditure propensities of endogenous accounts remain constant; and that production technology and resource endowments are given for a period. Therefore, the SAM-based multiplier model inherits the assumptions of the traditional input-output analysis (Alarcon, 2000).This accounting multiplier matrix is derived at constant prices and it is therefore constructed by “fixed-price” multipliers in a formal sense. The SAM-multiplier model is driven by changes in exogenous demand and solve for a resulting change in supply and demand that balances all endogenous accounts.

Breisinger *et al* (2009) used matrix algebra and two-sector SAM to derive the multiplier formula as follows:

The numbers in the SAM are replaced with letters or symbols referring to these in the equations as shown in table 2.

**Table 2: SAM in Letters or Symbol**

| | Activities | | Commodities | | Factors | Household | Exogenous demand | total |
|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $C_1$ | $C_2$ | F | H | E | |
| $A_1$ | | | $X_1$ | | | | | $X_1$ |
| $A_2$ | | | | $X_2$ | | | | $X_2$ |
| $C_1$ | $Z_{11}$ | $Z_{12}$ | | | | $C_1$ | $E_1$ | $Z_1$ |
| $C_2$ | $Z_{21}$ | $Z_{22}$ | | | | $C_2$ | $E_2$ | $Z_2$ |
| F | $V_1$ | $V_2$ | | | | | | V |
| H | | | | | $V_1 + V_2$ | | | Y |
| E | | | $L_1$ | $L_2$ | | S | | E |
| total | $X_1$ | $X_2$ | $Z_1$ | $Z_2$ | V | Y | E | |

Where:

$X_1$ and $X_2$ are gross output of each activity,

$Z_1$ and $Z_2$ is total demand for each commodity

V is total factor income, Y is total household income and E is exogenous components of demand.

The basic approach to SAM-based multiplier models is to compute column shares from a SAM, a coefficients matrix called “M-matrix (table 3).

**Table 3: M- matrix**

| | Activities | | Commodities | | Factors | Household | Exogenous demand | total |
|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $C_1$ | $C_2$ | F | H | E | |
| $A_1$ | | | $b_1=X_1/Z_1$ | | | | | $X_1$ |
| $A_2$ | | | | $b_2=X_2/Z_2$ | | | | $X_2$ |
| $C_1$ | $a_{11}=Z_{11}/X_1$ | $a_{12}=Z_{12}/X_2$ | | | | $c_1=C_1/Y$ | $E_1$ | $Z_1$ |
| $C_2$ | $a_{21}=Z_{21}/X_1$ | $a_{22}=Z_{22}/X_2$ | | | | $c_2=C_2/Y$ | $E_2$ | $Z_2$ |
| F | $v_1=V_1/X_1$ | $v_2=V_2/X_2$ | | | | | | V |
| H | | | | | 1 | | | Y |
| E | | | $l_1=L_1/Z_1$ | $l_2=L_2/Z_2$ | | $s=S/Y$ | | E |
| total | 1 | 1 | 1 | 1 | 1 | 1 | E | |

Where,

a’s are technical coefficients, b’s are the share of domestic output in total demand, v’s are the share of value-added in gross output, l’s are the share of the value of total demand from imports or commodity taxes, c’s are household consumption expenditure shares and s’s are the household savings rate.

Using the symbols in the SAM, total demand Z in each sector is the sum of intermediate input demand, household consumption demand, and other exogenous sources of demand E, such as public consumption and investment. This is shown in the equations 1.

$$Z_1 = a_{11}X_1 + a_{12}X_2 + c_1Y + E_1$$
$$Z_2 = a_{21}X_1 + a_{22}X_2 + c_2Y + E_2 \qquad (1)$$

From the SAM, the gross output X is only part of total demand Z, thus:

$$X_1 = b_1Z_1 \quad , \text{ and } \quad X_2 = b_2Z_2 \qquad (2)$$

The total household income depends on the share of factors’ earnings in each sector, as shown in Equation 3.

$$Y = v_1X_1 + v_2X_2 \qquad (3)$$

Substituting Equation 2 into 3 gives the following identity for total income Y.

$$Y = v_1b_1Z_1 + v_2b_2Z_2 \qquad (4)$$

Replacing X and Y in Equations 1 using Equations 2 and 4

$$Z_1 = a_{11}b_1Z_1 + a_{12}b_2Z_2 + c_1(v_1b_1Z_1 + v_2b_2Z_2) + E_1$$
$$Z_2 = a_{21}b_1Z_1 + a_{22}b_2Z_2 + c_2(v_1b_1Z_1 + v_2b_2Z_2) + E_2 \qquad (5)$$

Moving all terms, except for exogenous demand E, into the left-hand side, result in equations 6

$$Z_1 - a_{11}b_1Z_1 - c_1v_1b_1Z_1 - a_{12}b_2Z_2 - c_1v_2b_2Z_2 = E_1$$
$$-a_{21}b_1Z_1 - c_2v_1b_1Z_1 + Z_2 - a_{22}b_2Z_2 - c_2v_2b_2Z_2 = E_2 \qquad (6)$$

Grouping Z terms together, provide equation7.

$$(1 - a_{11}b_1 - c_1v_1b_1)Z_1 + (-a_{12}b_2 - c_1v_2b_2)Z_2 = E_1$$
$$(-a_{21}b_1 - c_2v_1b_1)Z_1 + (1 - a_{22}b_2 - c_2v_2b_2)Z_2 = E_2 \qquad (7)$$

Matrix algebra is used to convert equations 7 into matrix format as follows:

$$\begin{pmatrix} 1 - a_{11}b_1 - c_1v_1b_1 & -a_{12}b_2 - c_1v_2b_2 \\ -a_{21}b_1 - c_2v_1b_1 & 1 - a_{22}b_2 - c_2v_2b_2 \end{pmatrix} \begin{pmatrix} Z_1 \\ Z_2 \end{pmatrix} = \begin{pmatrix} E_1 \\ E_2 \end{pmatrix} \qquad (8)$$

The first term in Equation 8 is the identity matrix (I) minus the coefficient matrix (M).

$$\begin{pmatrix} 1 - a_{11}b_1 - c_1v_1b_1 & -a_{12}b_2 - c_1v_2b_2 \\ -a_{21}b_1 - c_2v_1b_1 & 1 - a_{22}b_2 - c_2v_2b_2 \end{pmatrix} = 1 - M \qquad (9)$$

Renaming the other two vectors Z and E, equation 8 can be expressed as:

$$(1 - M)Z = E \qquad (10)$$

Finally, by rearranging terms, the multiplier formula can be calculated as.

$$Z = (I - M)^{-1} E \qquad (11)$$

**Model Results and Discussion**

Two types of exogenous injection have been assessed, the first one is increase in demand for each commodity (due to increase in exports or government expenditure or inventory demand); the second one is injection in the household account (as a result of increasing government transfers or remittance). The impact of any given injection into the exogenous accounts of the SAM is transmitted through the interdependent SAM system among the endogenous accounts.

The interpretation of the values in the multiplier is straightforward. When read column-wise, the values show the increase of income in each of the four endogenous elements due to one unit of external injection into the column element via the exogenous accounts. Thus it shows, column-wise, the increase in the gross outputs of the sectors, commodity expenditure, income of the factors of production and income of the households on all the items respectively.

The results show that an injection of one SD billion (bln) in the commodity accounts generates highest additional expenditure on the commodity itself and it has the highest impact on the sector that produce it.

For example injection of one billion in agricultural account generates 2.38 bln extra expenditure on agricultural commodities and 2.12 bln increase in agricultural output. On the other hand the same injection yields an increase of 0.63 bln and 2.1 bln in industrial and service commodities respectively, with an increase of 0.58 bln and 1.82 bln in their respective outputs (table 4).

The results also indicate that, the service sector recorded the greatest response (2.63 bln) when exogenous injection took place. In addition it has the largest share in injection after the account in which the injection took place.

Considering the injection of one SD billion in household account, the results reveal that the account itself (household) benefits more (3.69 bln) than the other accounts, with the service sector witness the second response.

**Table 4: Multiplier effect ( billion) of Exogenous Shock on Endogenous Accounts**

| Accounts | | Commodities | | | Household |
|---|---|---|---|---|---|
| | | agric | ind. | serv. | |
| Activities | agric | 2.12 | 1.34 | 1.23 | 1.40 |
| | Ind. | 0.58 | 1.57 | 0.60 | 0.69 |
| | Serv. | 1.82 | 1.82 | 2.63 | 2.11 |
| commodities | agric | 2.38 | 1.51 | 1.38 | 1.58 |
| | Ind. | 0.63 | 1.72 | 0.65 | 0.75 |
| | Serv. | 2.10 | 2.11 | 3.05 | 2.44 |
| Factor of production | Lab. | 0.79 | 0.81 | 0.86 | 0.77 |
| | Cap. | 2.35 | 2.14 | 2.15 | 2.05 |
| household | | 2.99 | 2.81 | 2.86 | 3.69 |

**Source: Multiplier model**

**Types of Multiplier Impacts on Endogenous Accounts via Exogenous Instruments**

Four types of multipliers can be distinguished since the present multiplier framework has four endogenous accounts:

1. Gross output multiplier, it indicates the total effect on sectoral gross output of a unit-income increase in a given account.

2. Value added or GDP multiplier, it estimates the total change in GDP resulting from the same unit-income injection.

3. Consumption multiplier, it shows the total change in the consumption of basic needs resulting from the unit-income injection.

4. Household income multiplier, it reveals the total effect on household income of a unit-income increase in a given account.

Table (5) reveals that one billion injection in industry demand leads to higher output (4.74 bln) and consumption (5.34 bln) multiplier effect in the economy than injection in other accounts, which indicate its high integration with other sectors.

In case of the GDP multiplier the results show that agriculture sector generates higher GDP multiplier (3.14 bln) than industry (2.95 bln) and services (3.0 bln) sectors, indicating its high contribution in the value additions. Thus it can be seen that the sector that produce high gross output multipliers (industry in this case) do not automatically generate high GDP multipliers (agriculture). This can be attributed to high leakages effect in industrial sector.

Highest household income multiplier is achieved when the injection is directly located in the household account, followed by injection in the agricultural sector confirming the fact that more than 70% of Sudan population is generating their income from agricultural sector. Thus the development of agricultural sector is vital to eradicate poverty in Sudan.

**Table 5: Impact of Total Multiplier on Output, GDP, Household Income and Consumption**

| Multiplier | Commodity | | | Household |
|---|---|---|---|---|
| | agric | Ind. | serv | |
| **Output** | 4.51 | 4.74 | 4.46 | 4.20 |
| **GDP** | 3.14 | 2.95 | 3.00 | 2.82 |
| **Household income** | 2.99 | 2.81 | 2.86 | 3.69 |
| **Consumption** | 5.12 | 5.34 | 5.08 | 4.77 |

**Source: calculated from the Multiplier model**

## Implication on policy formulation:

As agriculture still employs the majority of the population, there is advantage of poverty mitigation by injection in the agricultural sector as evident by the comparative improvement in household income and higher GDP should the injection takes place in the agricultural sector.

The comparatively high output multiplier generated by injection in the industry sector indicates a likelihood of using resources more efficiently should the focus remains growth of the economy.

## Model limitation

The limitation of the SAM- based model is arising from the model assumptions. First, there is an excess capacity in all sectors and unemployed factors of production. In this case the multipliers work through to the equilibrium solution, but if there are capacity constraints of any kind then the multipliers will overestimate the total effects and the final distributional effects will be uncertain.

Secondly, as prices are fixed and it is static in nature, thus there is no allowance for dynamism or substitution effects anywhere, or at any stage. Again this may also lead to an overestimation of the total response. Thirdly, when prices are not fixed they may be expected to rise (fall) to offset excess demands (supplies) in any of the markets. Therefore any price changes would tend to mitigate the total effects implied by the fixed price model.

**Future work**

1. A decomposition of SAM multiplier is a very important step in SAM-based model, to add an extra degree of transparency in understanding the nature of linkage in an economy and the effects of exogenous shocks. This is hindered in this study due to the structure of Sudan SAM for year 2000, which does not reflect the intra-household transfers.

2. Calculation of SAM- based multiplier, based on marginal propensities instead of average propensities is needed to relax the assumption of unity elasticity of all income expenditure to provide an insight into economic behavior. In this case the assumption of fixed price is still there, so a more comprehensive approach as Computable General Equilibrium (CGE) model is needed to capture all the limitation of the SAM- based modeling.

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