Background Paper Series

PROVIDE

PROJECT

The Provincial Decision-making Enabling Project

Background Paper 2003: 4

Social Accounting Matrices and Economic Modelling

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PROVIDE PROJECT

The Provincial Decision-making Enabling Project

Overview

The Provincial Decision-Making Enabling (PROVIDE) Project aims to facilitate policy design by supplying policymakers with provincial and national level quantitative policy information. The project entails the development of a series of databases (in the format of Social Accounting Matrices) for use in Computable General Equilibrium models.

The National and Provincial Departments of Agriculture are the stakeholders and funders of the PROVIDE Project. The research team is located at Elsenburg in the Western Cape.

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For the original project proposal and a more detailed description of the project, please visit www.elsenburg.com/provide

Social Accounting Matrices and economic modelling[1]

Abstract

A Social Accounting Matrix (SAM) is a comprehensive, economy-wide database that contains information about the flow of resources associated with all transactions that have taken place between economic agents in an economy during a given period of time. Its use can extend beyond that of serving as a summary of transactions that have taken place in an economy. The SAM approach to modelling makes use of the SAM format to present economic theory. The versatility of SAMs has made them databases of preference for economic modelling. This paper provides an overview of the structure of a SAM, touching on issues such as economic accounting, the circular flow of resources in the economy and the SAM-accounts, and thereafter explains the SAM approach to modelling. As such the paper serves as a reference framework for users of SAMs.

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[1] The main author of this paper is Kalie Pauw, Senior Researcher of the PROVIDE Project.

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1.   Introduction

Social Accounting Matrices (SAMs) have become the database of preference for most macroeconomic modellers. A SAM is a comprehensive, economy-wide database that contains information about the flow of resources associated with all transactions that have taken place between economic agents in a certain economy during a certain period of time. As such it presents a snapshot picture of the economy at hand.

     Initial theoretical developments in social accounting are largely attributable to Sir Richard Stone who addressed the matter of integrating disaggregated production accounts (in the form of input-output systems)[2] into the national accounts. The aim was to form an economy-wide database, which not only included information about productive activities in the economy, but also incorporated other non-productive institutions and markets, such as factor markets, capital markets, households, government, and the rest of the world.

     This paper provides an overview of social accounting and is organised as follows. Section 2 provides an overview of social accounting and the way in which the circular flow of resources is captured in a SAM. Section 3 describes the SAM approach to modelling. Section 4 makes some concluding remarks.

2.   An overview of SAMs

2.1.   Economic accounting

A SAM can be described as a "*comprehensive, economy-wide data framework*" (Löfgren et al, 2001: 2) presented in the form of a square matrix. It has two principle objectives: firstly, to organise information about the economic and social structure of an economy (e.g. a region or a country) in a specific period (usually one calendar year), and secondly, to provide the statistical basis for the creation of plausible economic models (King, 1985: 17).

     When economic agents are involved in transactions with each other financial resources exchange hands. The first objective of a SAM is to organise data. For this purpose accounts are included in the SAM to represent agents that are involved in economic transactions. Transactions are captured in the relevant accounts of the SAM, showing the values and direction of the flow of resources. A SAM thus forms a complete database of all transactions that take place between agents in a given period, presenting a 'static image' or 'snapshot picture' of the structure of an economy for that period.

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[2] Input-output analysis was developed by Wassily Leontief in the 1930's. Its primary aim is to provide a tool to analyse the production side of the economy, with a specific focus on the intermediate input requirements and final outputs of industries.

SAM accounts are created for all economic agents, including producers, households, government and the rest of the world. Accounts also exist for commodity, factor and capital markets. Some SAM accounts can therefore be seen as intermediate clearing accounts. For example, the transactions recorded in a SAM are not limited to the purchase or selling of goods and services but can incorporate any type of transaction. This includes transactions that take place during the production process such as the purchasing of intermediate goods and hiring of factors. It also includes current account transactions of institutions (households, enterprises and government), such as inter-institutional transfers, consumption expenditure and the payment of various taxes. It further includes capital account transactions of institutions, such as savings and investments. Finally, it can include any transaction that takes place across international borders, such as direct foreign investment and international trade transactions.

An important property of a SAM is that transaction values are reported in a consistent manner. Each account entry clearly shows the value of the transaction as well as the accounts that are debited and credited.

> "Economic accounting is based on a fundamental principle of economics: For every income or receipt there is a corresponding expenditure or outlay. This principle underlies the double-entry accounting procedure that makes up the macroeconomic accounts of any country." (Reinert and Roland-Holst, 1997: 95)

The consistency of a SAM stems from the fact that it adheres to the fundamental principle of economics described in the quotation above. In financial accounting double entry bookkeeping is performed with the aid of various T-accounts with debit and credit entries. For example, a government transfer of R1000 to households would be accounted for as follows (Figure 1):

Figure 1: T-accounts for government-household transfer

Exp.	**Government**	Inc.	Inc.	**Households**	Exp.
Transfers paid R1000				Transfers received R1000	

Since resources flow from the government account to the households account, the former is debited and the latter is credited with R1000. The SAM approach to bookkeeping is much more concise. A SAM is a square matrix where column of the SAM represents a specific account in the economy. The exact same accounts also appear in the rows. Incomes or receipts

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are shown in the rows of the SAM, i.e. if households receive R1000 the amount should appear in one of the cells along the household row account. Expenditures or outlays are shown in the column, i.e. if government parts with R1000 the amount should appear in the government column account. In the government transfer example used here the transfer can be entered in the cell where the government column and household row accounts intersect (Table 1). In general, a single-cell entry in row *i* and in column *j* represents a flow of resources from account *j* to account *i*.

Table 1: A transfer from government to households

	...	Government	...	...
...	...	...	...	...
...	...	...	...	...
Households	...	1000	...	...
...	...	...	...	...

In financial accounting each account is balanced at the end of the financial period. The debit side equals the credit side and profits or losses are matched off with an entry in a profit or loss account. Similarly, in a SAM, the income of each account (row total) must equal the expenditure of each account (column total). This holds for individual accounts, but also for the economy as a whole. A SAM thus goes further than T-accounts. Where T-accounts are balanced individually, a SAM ensures that all accounts are simultaneously balanced. For this reason a SAM can be described as complete and consistent. Since all transactions are captured in a SAM, a discussion of the circular flow in the economy may help to understand the concept of a SAM better.

2.2.   Circular flow in the economy

The conventional way to present a circular flow diagram is to show the movement of goods and services through the economy. Since a SAM is interested in the flow of *resources* in the economy, the arrows in Figure 2 point in the opposite direction.

Figure 2: The flow of resources in a multisector economy
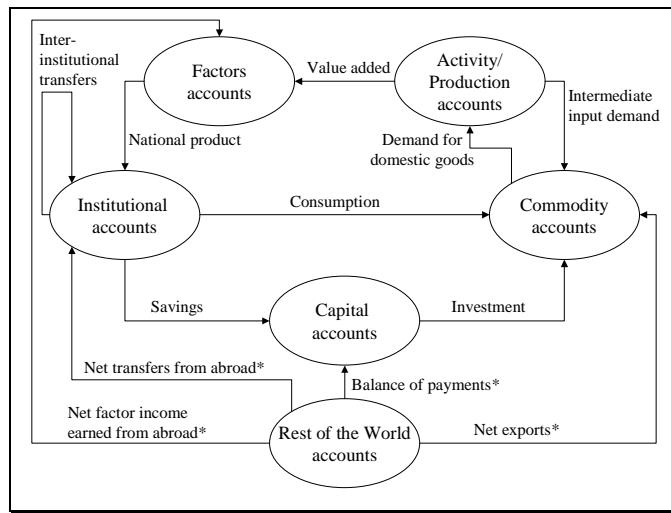
Notes: 1) Government, households and incorporated business enterprises are all regarded as institutions. Although some inter-institutional tax transfers and tax transfers from factors to government are captured in Figure 2, tax payments from activities and commodities have been omitted for simplicity reasons.

2) Flows indicated with a star (*) can be in the opposite direction as well. These are mainly flows associated with the rest of the world accounts. For example, if imports exceed exports there would be a flow from the commodity account to the rest of the world account. Similarly for net transfers from (to) abroad, the balance of payments etc.

Figure 2 can be explained by starting with the commodity accounts. Resource flows into these accounts originate from the rest of the world (net exports), capital accounts (investment demand), the institutional accounts (household and government consumption), and the activity accounts (intermediate input demand). The combined income of these accounts pays for domestic demand from the activity accounts as well as commodity taxes to the institutional accounts (not shown).

Activities are involved in production; hence the activity accounts are also called production accounts. Final goods supplied to the commodity accounts are produced by employing factors that add value to intermediate inputs purchased from the commodity accounts. These resource flows are represented by payments to the factor accounts and the commodity accounts respectively. Factor use taxes or production taxes may also be payable to government in the institutional accounts (not shown).

Apart from receiving remuneration from the activity accounts, factors supplement their income with transfers from abroad (rest of the world accounts). Since factors are 'owned' by institutions, factor account income is paid to the institutional accounts. Typically households own capital and/or labour, while enterprises and government may own capital. Since transactions also take place between institutions, inter-institutional transfers are also included

in the figure. These include tax payments from households and enterprises to government, inter-household transfers, transfers from government to households such as social security grants, and all other inter-institutional transfers. Inter-institutional transfers can easily be identified in the more detailed institutional breakdown typically used in a SAM (see section 2.3). Net transfers from abroad supplement institutions' income, provided these are positive.

All income not spent by households, enterprises and government is saved. Government savings can be negative (budget deficit) or positive (budget surplus). Institutional savings flow from institutional accounts to the capital accounts. A positive balance of payments would also contribute to the pool of savings. The entire pool of savings is utilised for investment purposes. This is shown here as a flow from in the capital accounts to the commodity accounts, i.e. investment goods are purchased from the commodity accounts. The following section proceeds to explain how these flows can be represented in a SAM-format that uses the same accounts as those in Figure 2. It will however be shown that greater detail is now possible since accounts can easily be disaggregated into various sub-accounts.

2.3.   The accounts of a SAM

SAMs are usually constructed with six types of accounts that relate directly to those in Figure 2 above. Each of these accounts can be disaggregated further should more detailed information be available or necessary from a modelling perspective. Table 4 shows the structure of a SAM using these accounts. In this SAM the institutional accounts are disaggregated into separate accounts for households, incorporated business enterprises and government. Each account is represented by a row and a column in the SAM, where row entries represents flows into the account, while column entries represent flows from the account. An important feature is that each account must be balanced, i.e. flows into the account must match flows from the account.

The commodity accounts show all transactions relating to intermediate input demand, institutional consumption demand and investment demand. The row accounts show how commodities are distributed between intermediate input demand (USE matrix) and final demand. Final demand is made up of consumption demand by households, governments and enterprises (if applicable). It also includes investment demand and export demand from the rest of the world. All domestically consumed commodities are valued at the same price, which is inclusive of all relevant sales taxes and tariffs. Thus, all prices along the row are the same irrespective of which agent purchases the commodity. This is the so-called law of one price. The inclusion of exports in the same row is slightly misleading, as exports are usually valued at export prices, which are a function of exogenously determined world prices.[3]

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[3] See *Technical Paper 2003: 3* for a more detailed discussion. Also see the discussion in section 3.

Domestic production is contained in the MAKE matrix along the row of the activity accounts and the commodity account column. Total domestic supply is made up of domestically produced goods as well as imported goods. The SAM therefore separates imports from exports. Apart from expenditure on intermediate inputs, activities pay for value-added, which is represented by a flow from the activity accounts to the factor accounts. Adding production taxes gives total activity expenditure, which equals activity income from the commodity accounts.

Factors earn income from employment in domestic production activities. They can, however, also earn income from abroad. The income of the factor capital is usually in the form of profits and rent, while labour earns wages. The factor column account shows how factor income is disbursed. Institutions, the owners of factors, receive income from factors net of factor taxes such as social security payments or taxes on profits. Factor income is typically in the form of wage-income or distributed profits. Transfers from factors to the rest of the world can also be included in the SAM.

There are three institutional accounts in the SAM in Table 2. Households' usually earn the majority of their income from factors, but can also supplement this with transfers from other institutions or the rest of the world. Total household income is distributed between consumption, transfers to other households, direct taxes and savings. Incorporated business enterprises earn income from non-distributed firm profits and transfers. Surplus income is distributed between taxes and transfers to other institutions, transfers to the rest of the world, and enterprise consumption (if applicable) and savings. Government receives income from various tax sources, from the ownership of factors (if applicable), and from transfers from other institutions and the rest of the world. Expenditure is made up of transfers and government consumption demand.

The capital accounts contain all transactions relating to investment and the funding thereof. Domestic institutions and the rest of the world can contribute to the pool of savings as shown in the capital row account. Savings are injected in the economy in the form of direct investment, which is captured as demand for commodities. Finally, the rest of the world account(s) record all transactions between domestic institutions, factors or commodity accounts and the rest of the world.

An important feature of a SAM is that the jth row total should equal the jth column total, i.e. for each account, income or receipts should equal its expenditure or outlay. This feature of a SAM ensures compliance with the basic economic accounting principle. If this does not hold, the SAM is either incomplete or inconsistent. This means that certain transactions are not recorded, or certain SAM entries do not properly match the agents involved in the transactions. Consider the previous example of a government transfer to households. If

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households report income from transfers of R980, while government budget accounts suggest that the transfer was R1000, the accounts are not reconciled and the SAM will not balance.

There is also an important difference between balancing a SAM and estimating a SAM. When SAM-entries are missing, but there is reason to believe that the specific transaction did take place, it is necessary to estimate the missing value. Once all available data, whether observed or estimated, has been included in the SAM, it is still unlikely to balance due to data inconsistencies and estimation errors. Such a SAM then has to be balanced. Various statistical techniques can be used to remove 'small' errors, which will ensure that the SAM balances. The difficulty with balancing a SAM has to do with the fact that any change to row entries will automatically affect various column totals. Rows and columns must therefore be adjusted simultaneously. A discussion of the various balancing/estimation methods falls beyond the scope of the paper.

Table 2: A macroeconomic SAM

Expenditures→ Receipts↓	1. Commodities	2. Activities	3. Factors	4. Households	5. Enterprises	6. Government	7. Savings investment	8. Rest of the world	TOTAL
1. Commodities		Intermediate inputs (USE matrix)		Private consumption		Government consumption	Investment	Exports	Demand
2. Activities	Domestic production (MAKE matrix)								Activity income (gross output)
3. Factors		Value-added						Factor income from RoW	Factor income
4. Households			Factor income to households	Inter-household transfers	Transfers to households	Transfers to households		Transfers to households from RoW	Household income
5. Enterprises			Factor income to enterprises			Transfers to enterprises		Transfers to enterprises from RoW	Enterprise income
6. Government	Sales taxes, tariffs, export taxes	Indirect taxes, factor use taxes	Factor income to government, factor taxes	Transfers to government, direct household taxes	Transfers to government, direct enterprise taxes			Transfers to government from RoW	Government income
7. Savings-investment				Household savings	Enterprise savings	Government savings		Balance of payments	Savings
8. Rest of the world	Imports		Factor income to RoW		Transfers to RoW	Government transfers to RoW			Foreign exchange outflow
TOTAL	Supply	Activity expenditures	Factor expenditures	Household expenditure	Enterprise expenditure	Government expenditure	Investment	Foreign exchange inflow	

Source: Löfgren et al (2001)

Next we consider some simple examples, first of a closed economy without a government sector, and secondly of an open economy with a government sector. These examples show how the various accounts can be disaggregated further to include more detailed information about the structure of the economy.

2.3.1.   Example 1: Closed economy with no government sector

In this example data from a basic two-sector economy with only firms and households is provided (adapted from Löfgren, 1999). There are two markets, one for factors and one for commodities. Households earn all their income from labour and capital, which they supply to the factor market. They spend all their income on consumption, i.e. there is no capital account to which they can transfer their savings. There is also no government sector and hence households do not pay taxes nor do they receive income from government transfers. There is also no foreign sector, i.e. our economy is closed. In this example, as with the one that follows (section 2.3.2), it is assumed that each industry only produces a single product. This implies a diagonal MAKE matrix. In larger more disaggregated SAM's it is often necessary to relax this limiting assumption by allowing multi-product producers, i.e. the MAKE matrix will then have off-diagonal entries.

Table 3: SAM for a closed economy with no government sector

	AGR-C	NAGR-C	AGR-A	NAGR-A	LAB	CAP	U-HHD	R-HHD	TOTAL
AGR-C			60	40			50	75	225
NAGR-C			40	60			100	50	250
AGR-A	225								225
NAGR-A		250							250
LAB			62	55					117
CAP			63	95					158
U-HHD					60	90			150
R-HHD					57	68			125
TOTAL	225	250	225	250	117	158	150	125	

Source: Löfgren (1999)

The commodities account is disaggregated into agricultural (AGR-C) and non-agricultural (NAGR-C) commodities. Similarly, activities are disaggregated into agricultural activities (AGR-A) and non-agricultural activities (NAGR-A). Producers buy intermediate inputs in the commodity markets and use their factors of production in the production process to add value to intermediate inputs and produce final goods. These goods are then sold on the commodity market, either as final consumption by households or as intermediate inputs demanded by

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producers. Factors of production consist of labour (LAB) and capital (CAP). The only institutions included in the model are households. Households are disaggregated into urban (U-HHD) and rural (R-HHD) households. No government sector is included. Since this is a closed economy there is also no account for the rest of the world.

The amounts that appear in this SAM all refer to the flow of resources between agents in monetary terms. Receipts appear in the rows, while expenditures appear in the columns. Agricultural activities purchase agricultural commodities (60) and non-agricultural commodities (40) as intermediate inputs into their production process. The amounts paid for labour (62) and capital (63) represent value added. The total value of agricultural production amounts to 225. In the absence of government no production taxes are payable. The agricultural commodities are sold on the agricultural commodity market for 225. Similarly, non-agricultural activities produce goods to the value of 250, which is then also sold on the non-agricultural commodity market for 250. The income of activities is captured as an entry in the activity row and the commodity column. The income and expenditure of all activities are thus in equilibrium.

As mentioned above, activities consume some of the production as intermediate inputs. Households consume the balance of commodities produced. Urban households consume 50 worth of agricultural commodities and 100 worth of non-agricultural commodities. Rural households spend 75 and 50 on these two commodities respectively. Final household consumption of agricultural commodities equals 125. This, combined with the 100 spent by producers on agricultural commodities as intermediate goods, gives a total resource flow of 225 into the agricultural commodities account. Similarly households spend 150 on non-agricultural commodities, while producers spend 100, making up the total value of 250 spent on non-agricultural commodities.

In this SAM we make the assumption that households derive their entire income from the factor market, i.e. we assume that households own factors of production and supply these factors on the factor market in exchange for remuneration. This remuneration is exactly equal to the value-added payments of activities. Urban households earn 60 from labour and 90 from capital employed in the production process. Rural households earn 57 from labour and 68 from capital. The total income earned by households is spent on consumption. Thus, in the absence of a capital account (savings) and a government account (taxes), household income and expenditure balances out.

2.3.2.   *Example 2: Open economy with a government sector and a capital account*

In the second example a government sector is added, as well as a capital account for the institutions (households and government) and an account for the rest of the world. The

inclusion of the government sector has tax implications for various agents. Various tax accounts are included, namely accounts for income tax (YTAX) payable by households, sales taxes (STAX) payable by the commodity market and import tariffs (TAR) payable by the commodity market on imported goods. A core government account (GOV) represents the government budget. The capital account (S-I) or savings-investment account captures savings and investment by institutions. The inclusion of the rest of the world account (ROW) also allows for foreign capital and current account transactions to be captured. Consider Table 4 below.

Table 4: SAM for an open economy with a government sector and a capital account

	AGR-C	NAGR-C	AGR-A	NAGR-A	LAB	CAP	U-HHD	R-HHD	GOV	S-I	YTAX	STAX	TAR	ROW	TOTAL
AGR-C			84	55			30	49	13	28				30	289
NAGR-C			50	99			165	92	67	85					558
AGR-A	279														279
NAGR-A		394													394
LAB			72	105											177
CAP			73	135											208
U-HHD					95	125			25					40	285
R-HHD					82	83			5					16	186
GOV											25	30	39	15	109
S-I							70	40	-1					4	113
YTAX							20	5							25
STAX	10	20													30
TAR		39													39
ROW		105													105
TOTAL	289	558	279	394	177	208	285	186	109	113	25	30	39	105	

Source: Löfgren (1999)

The column account of the commodities market is different to the previous SAM due to the introduction of government. The commodity account is now required to pay sales taxes to the amount of 10 for agricultural commodities and 20 for non-agricultural commodities. Furthermore, import duties are payable on imported commodities. We make the assumption that only non-agricultural commodities are imported, hence no import tariff is payable on agricultural commodities. Non-agricultural commodities to the value of 105 are imported from the rest of the world. A tariff of 39 is payable on these imports. The row account of the commodity market is also altered. As before, activities consume intermediate goods households consume final goods. However, in addition to this, government and the rest of the world also now consume goods. Government spends 13 and 67 on agricultural and non-agricultural products respectively, while the rest of the world pays 30 for agricultural commodities. We assume that only agricultural commodities are exported to the rest of the world.

The column (expenditure) accounts of activities remain the same as before, i.e. producers purchase intermediate inputs from the commodity markets and add value through the use of factors of production, labour and capital. The total value of agricultural production is 279, while the value of non-agricultural production is 394. As before, producers sell these products on the commodity markets and receive revenue equal to the amounts spent on intermediate inputs and factors (value added).

The factor accounts are unchanged. Factors receive income from value added payments by producers. Households, the owners of these factors, in turn derive part of their income from factors. In some cases factor taxes (e.g. a capital asset tax) can be included. However, in this SAM no provision is made for factor taxes. The column accounts of households now include household savings (70 and 40 for urban and rural households respectively), as well as payments to the income tax account of government (20 and 5 for urban and rural households respectively). Household income is supplemented by transfers from government (25 and 5 for urban and rural households respectively) and transfers from the rest of the world (40 and 16 for urban and rural households respectively).

Government receives revenue from the various tax sources (25, 30 and 39 from income taxes, sales taxes and import tariffs) as well as transfers from the rest of the world (15). Government thus receives a total income of 109 from these sources. This can now be spent on government consumption expenditure and transfers to households. The remainder of government revenue is saved. In this example government savings are negative, i.e. they run a budget deficit and need to borrow money in order to balance budget. An alternatively to this negative entry in the SAM would have been to include a +1 in the capital account column.

The income of the capital account includes institutional savings and the balance of payments, while expenditure is made up of investment demand. Investment is captured in a similar way as consumption of institutions, i.e. it appears in the commodities row account. Since all the other accounts are in balance, the rest of the world account will be in balance. The rest of the world account receives income from the sale of exports. As mentioned above, the commodity market imports non-agricultural commodities to the value of 105. The rest of the world imports 30 worth of agricultural commodities. Domestic institutions also receive transfers from the rest of the world. The balance of payments is equal to 4.

3. A SAM approach to modelling

The preceding sections showed how a SAM provides a quantitative picture of the economy by summarising the resource flows between agents that are involved in transactions. Pyatt (1988) refers to this as the transactions value (TV) approach to social accounting. However, the SAM-format can also be used to present economic theory, i.e. it can provide both an empirical and a theoretical description of the economy. This section draws on Pyatt's "SAM approach to modelling" (1988).

The TV approach involves obtaining numerical estimates of the transaction values or resource flows between agents. Economic theory can be presented by replacing the transactions values by algebraic expressions that describe how the transaction might be determined. The value of any transaction is simply its price times the quantity. Each algebraic expression is therefore a function of income, conditioned upon prices. The entry in the jth row and k^{th} column of the SAM, t_{jk}, is defined as

$$t_{jk} = t_{jk}\left(y; p, f, \lambda\right) \qquad\qquad\qquad [3.1]$$

Thus, the value of any transaction is a function of y, where y is a vector of account incomes, conditioned upon prices p, a vector of commodity and activity prices, f, a vector of factor prices and λ, the exchange rate. This contrasts the more conventional way of expressing economic theory whereby quantities are expressed as a function of prices. In the SAM approach transactions values are functions of income (which relates to the scale of output), conditional upon prices.

Pyatt (1988) uses a simple proof to show how prices in a column account for commodities or activities are interdependent although they relate to different commodities. The vector of row-sums of a SAM represents account incomes or total revenue (TR). Similarly, the vector of column-sums represents total outlay or cost (TC). The basic underlying accounting identity, which requires that the sum of the jth row should equal the sum of the jth column, implies that TR equals TC and hence average revenue (AR) equals average cost (AC), which is dependent

on prices. Therefore, prices are interdependent and column summation of the commodity or activity accounts in a SAM yields a set of equations

$$p = p(y; p, f, \lambda) \hspace{3cm} [3.2]$$

Equation 3.2 provides a general description of the price system and is the first set of three sets of equations of a macroeconomic (general equilibrium) model. The set of equations are linear homogenous, i.e. if input prices are doubled, output prices will also double, provided that the scale of production stays constant.[4] The interdependency of prices can easily be explained with the aid of a 3x3 matrix such as the one below, which represents a small SAM (commodity/activity accounts):

$$\begin{bmatrix} p_1 q_{11} & p_1 q_{12} & p_1 q_{13} \\ p_2 q_{21} & p_2 q_{22} & p_2 q_{23} \\ p_3 q_{31} & p_3 q_{32} & p_3 q_{33} \end{bmatrix}$$

Each matrix entry represents the transaction value and is made up of quantities and prices. Thus, the entry $p_i q_{ij}$ represents the transaction between accounts i (row, income) and j (column, expenditure), valued at price p_i. Summing along the row k of the matrix is possible, as prices and quantities are the same (they relate to the same commodity). Thus, the revenue of account k can be expressed as follows:

$$TR_k = \sum_j p_k q_{kj} = p_k Q_k \text{ , where } Q_k = \sum_j q_{kj} \hspace{2cm} [3.3]$$

Consequently, the average revenue of account k can simply be expressed as $AR_k = p_k$. Column summation is more problematic, as one now sums across different types of commodities and hence prices. Thus,

$$TC_k = \sum_i p_i q_{ik} \hspace{3cm} [3.4]$$

But, given that $TC_k = TR_k$, it follows that a change in p_i $(i \neq k)$ in a given column account that affects TC_k, will lead to a change in TR_k and hence p_k has to adjust to maintain the balance. However, when p_k changes it affects the TC and hence TR of the other columns as well. Thus, all prices are interdependent, as can be seen from the worked example below for $k = 1$:

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[4] This is ensured by using linearly homogenous production functions to model production in a model.

$$TR_1 = TC_1$$
$$p_1 q_{11} + p_1 q_{12} + p_1 q_{13} = p_1 q_{11} + p_2 q_{21} + p_3 q_{31}$$
$$p_1 (q_{12} + q_{13}) = p_2 q_{21} + p_3 q_{31}$$
$$\therefore p_1 = \frac{p_2 q_{21} + p_3 q_{31}}{q_{12} + q_{13}}$$

Pyatt (1988) makes use of a simple exposition to show how a system of equations for an economic model can be developed with the SAM as basis. The basic principle underlying Pyatt's SAM approach to modelling is that each entry in a SAM can contain either exogenous transaction that are independent on income or the scale of production or endogenous transactions that are dependent on income. The matrix of endogenous transactions is denoted by N and the matrix of exogenous transactions by X. A SAM can then be written as the sum of the endogenous and exogenous matrices, i.e. $T = N + X$, where T is a square matrix or SAM.

If y is the vector of row sums, i.e. y is the vector of account incomes of T, then

$$y = n + x \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\text{[3.5]}$$

where n and x are the vectors of row sums of N and X respectively. This vector equation represents the second set of model equations, the first being equation 3.2, the price system of the model. Equation 3.5 relates to the demand side of the system of equations. It simply explains how total income is derived from endogenous and exogenous demands.

Now, let $[x]$ denote the number of elements in a vector x. Equation 3.1 thus contains $[y] + [p] + [f] + 1$ variables, the total number of variables in the model (assuming that there is only a single element in the vector λ). The price system is made up of $[p]$ equations (equation 3.2), while the demand system contains $[y] - 1$ equations (equation 3.5). Note that one of the equations in the set y is linearly dependent on the others, which explains the reason for subtracting the one. Combining these two sets of equations gives $[p] + [y] - 1$ equations. Thus, there are $[f] + 2$ degrees of freedom.

In a system where all prices are flexible the system will only solve (or 'close') if a set of $[f] + 2$ equations known as closure rules are defined. The closure rules form the third and final set of equations in the model. In general (using the accounts in the SAM in Table 2) closure rules apply to three types of accounts, namely the government account, the capital account and the rest of the world account. Since the system is over-identified certain variables are fixed in order to reduce the degree of freedom. Economic theory and evidence should guide the modeller in defining the closure rules.

Each closure rule defines how equilibrium should be reached. Firstly, one has to decide whether government savings are fixed or flexible, i.e. how is the government budget

balanced? Secondly, are investments savings-driven or are savings investment-driven? Finally, do we assume a flexible or fixed exchange rate regime? These closure options can have a large impact on the results of model simulations and should be considered carefully.

At least one closure rule must not be linear homogenous, otherwise a solution will not be found. This is achieved by fixing one of the prices, the *numeraire*, in the system. Due to interdependency of prices all other prices can be expressed relative to the price of the *numeraire*.

4.   Concluding remarks and future research

This paper aimed to introduce the basic concepts of social accounting. A SAM is an ingenuous development that not only reconciles the production side of the economy with the rest of the economy, but also presents flows of resources associated with economic transactions in a concise way. SAMs are consistent and comprehensive because they adhere to the fundamental law of economic accounting and they capture all economic transactions between all agents. This ensures that a balance is maintained at a microeconomic level. They also capture the net flow of resources between agents in the economy, thus adding to our understanding of the structure of the economy. This ensures that macroeconomic balances are maintained. These features have contributed to the popularity of SAMs and their ever-increasing use as a statistical basis for multisector and macroeconomic modelling.

However, SAMs are not only used to show resource flows. Although a SAM in itself does not constitute an economic model, it can be used to present economic theory as illustrated by Pyatt (1988). The SAM approach to modelling is a useful way of showing how the model statement (price and demand system, behavioural equations and macroeconomic balances/closures) of a macroeconomic or general equilibrium model can be developed. It is also a useful way of helping to understand the process of calibration. The SAM approach to modelling clearly shows that the various properties of a SAM, particularly the fact that account row and column totals are balanced, are very important when a SAM is used as the database for a general equilibrium model.

There are some issues that have not been touched on in this paper that need further attention. It is envisaged that some or all of these topics will be added to a revised edition of this *Background Paper*. These include the following. Firstly, the price system underlying a SAM is important. This was only briefly mentioned in section 3 about the SAM approach to modelling. A revised edition will explain the distinction between basic prices (consumer prices) and purchaser prices and how these are related or interdependent. Also refer to *Technical Paper 2003: 3*.

Secondly, some issues surrounding production and trade need to be raised. Specifically, the incorporation of multi-product activities, how trade and transport margins are accounted for, and how multiple trade partners can be included in a SAM needs to be discussed. Some of these issues are discussed in *Technical Paper 2003: 3*.

Thirdly, the selection and the degree or level of disaggregation of accounts in a SAM was not mentioned in this paper. Although a macro-SAM will usually follow the basic structure presented in Table 2, the construction of a more detailed or disaggregated micro-SAM requires that some thought be given to the commodity/activity breakdown, the number and types of factors, the choice of representative household groups and whether multiple trade partners should be included in the rest of the world accounts. Forthcoming *Background Papers* on the formation of representative household groups and on South African international trade discuss some of these issues.

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