A 2009 Social Accounting Matrix (SAM) for South Africa

Rob Davies[a] and James Thurlow[b]

[a] *Human Sciences Research Council (HSRC), Pretoria, South Africa*
[b] *International Food Policy Research Institute, Washington DC, USA*

August 2013

Summary: This paper documents a South African Social Accounting Matrix (SAM) for the year 2009. The national SAM is built using official supply-use tables, national accounts, state budgets, and balance of payments, and so provides a detailed representation of the South African economy. It separates 49 activities and 85 commodities; labor is disaggregated by education level; and households by per capita expenditure deciles. Information on labor is drawn from the 2009 Quarterly Labor Force Survey and on households from the 2005 Income and Expenditure Survey. Finally, the SAM identifies government, investment and foreign accounts. It is therefore an ideal database for conducting economywide impact assessments, including SAM-based multiplier analysis and computable general equilibrium (CGE) modeling.

Suggested citation: Davies, R. and J. Thurlow (2013). A 2009 Social Accounting Matrix (SAM) for South Africa. Washington DC, USA: International Food Policy Research Institute.

Users' requirements

The users of A 2007 Social Accounting Matrix (SAM) Database for Zambia are required to both the dataset and this manual. The preferred citations are listed below:

Dataset: International Food Policy Research Institute (IFPRI). 2014. A 2009 Social Accounting Matrix (SAM) Database for South Africa. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://dx.doi.org/10.7910/DVN/24774

Data paper: Davies Rob; and Thurlow, James. A 2009 Social Accounting Matrix (SAM) for South Africa. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128029

Table of contents

List of acronyms

CGE Computable general equilibrium
GDP Gross domestic product
SAM Social accounting matrix
SUT Supply-use table

1. Introduction

This paper outlines the construction of a 2009 social accounting matrix (SAM) for South Africa. A SAM is a consistent data framework that captures the information contained in the national income and product accounts and the supply-use table (SUT), as well as the monetary flows between institutions. A SAM is an ex-post accounting framework since, within its square matrix, total receipts must equal total payments for each account contained within the SAM. Since the required data is not drawn from a single source, information from various sources must be compiled and made consistent. This process is valuable since it helps identify inconsistencies among statistical sources. For example, there are invariably differences between the incomes and expenditures reported in national household surveys. SAMs are economy-wide databases which are used in conjunction with analytical techniques to strengthen the evidence underlying policy decisions.

Section 2 reviews the general structure of SAMs and Section 3 presents the key features of the South African SAM. The first step in constructing the South African SAM is compiling national accounts and other official data sources into a consistent SAM framework. The second step then draws on survey information to disaggregate labor and household accounts. Given the diversity and inaccuracy of survey data sources, the prior SAM is invariably inconsistent (i.e., there are inequalities between household receipts and payments). Section 4 describes the data sources used to construct the prior SAM and the balancing procedure of SAM accounts.

This SAM was constructed in collaboration with the National Treasury of South Africa based on publically-available information provided by Statistics South Africa and the South African Reserve Bank.

2. General Structure of SAMs

A SAM is an economy-wide data framework that usually represents the real economy of a single country.[1] More technically, a SAM is a square matrix in which each account is represented by a row and column. Each cell shows the payment from the account of its column to the account of its row – the incomes of an account appear along its row, its expenditures along its column. The underlying principle of double-entry accounting requires that, for each account in the SAM, total revenue (row total) equals total expenditure (column total). Table 1 shows an aggregate SAM (with verbal explanations in place of numbers).

[1] For general discussions of SAMs and SAM-based modeling, see Pyatt and Round (1985), Reinert and Roland-Holst (1997), Pyatt (1988), Robinson and Roland-Holst (1988), and Breisinger, Thomas and Thurlow (2009).

The SAM distinguishes between ‘activities’ (the entities that carry out production) and ‘commodities’ (representing markets for goods and non-factor services). SAM flows are valued at producers’ prices in the activity accounts and at market prices (including indirect commodity taxes and transactions costs) in the commodity accounts. The commodities are activity outputs, either exported or sold domestically, and imports. In the activity columns, payments are made to commodities (intermediate demand), and factors of production (value-added comprising of operating surplus and compensation of employees). In the commodity columns, payments are made to domestic activities, the rest of the world, and various tax accounts (for domestic and import taxes). This treatment provides the data needed to model imports as perfect or imperfect substitutes vis-à-vis domestic production.

The government is disaggregated into a core government account and different tax collection accounts, one for each tax type. This disaggregation is necessary since otherwise the economic interpretation of some payments is often ambiguous. In the SAM, direct payments between the government and households are reserved for transfers. Finally, payments from the government to factors (for the labor services provided by public sector employees) are captured in the government services activity. Government consumption demand is a purchase of the output from the government services activity, which in turn, pays labor.

The SAM contains a number of factors of production, which earn incomes from their use in the production process, and then pay their incomes to enterprises, households, government and the rest of the world. Indirect capital earnings or enterprise profits are taxed according to average corporate tax rates and some profits may be repatriated abroad. The remaining capital earnings, together with labor earnings are paid to households. Households use their incomes to pay taxes, save, and consume domestically produced and imported commodities.

Table 1: Basic structure of a SAM

	Activities	Commod-ities	Factors	Enterprises	Households	Government	Investment	Rest of the World	Total
Activities		Marketed output			Home consump-tion				Activity income
Commodities	Inter-mediate inputs	Transaction costs			Marketed consump-tion	Government consump-tion	Investment, change in stocks	Exports	Total demand
Factors	Value-added							Foreign factor earnings	Factor earnings
Enterprises			Factor income to enterprises			Transfers to enterprises		Foreign enterprise receipts	Enterprise earnings
Households			Factor income to households	Indirect capital payments	Inter-household transfers	Transfers to households		Foreign remittances received	Household income
Government	Producer taxes	Sales taxes, import tariffs	Factor taxes	Corporate taxes	Personal taxes			Government transfers from rest of	Government income
Savings				Enterprise savings	Household savings	Government savings		Foreign savings	Savings
Rest of the World		Imports		Repatriated earnings	Foreign remittances paid	Government transfers to rest of world			Foreign exchange outflow
Total	Gross output	Total supply	Factor expenditure	Enterprise expenditure	Household expenditure	Government expenditure	Investment	Foreign exchange inflow	

Source: 2009 South African social accounting matrix.

3. Constructing the Prior Social Accounting Matrix

The initial task in building a SAM involves compiling data from various sources into the SAM framework. For South Africa, this information was drawn from national accounts, national supply-use tables, household and labor force surveys, government budgets and balance of payments. This information often uses (1) different disaggregation of sectors, production factors, and socio-economic household groups, (2) different years and/or base-year prices, and (3) different data collection and compilation techniques. Consequently, the initial or prior SAM inevitably includes imbalances between row and column account totals.

The macro SAM shown in Table 2 is an aggregation of the more detailed micro SAM. This section explains how each macro SAM entry is derived and disaggregated to arrive at the prior micro SAM. Each entry in the SAM is discussed below. The notation for SAM entries is (row, column) and the values are in billions of 2009 South African Rand. The final disaggregated SAM is quite large and is included in the accompanying spreadsheet file.

i. *(Factors, Activities)… 2,145*

This is the value of gross domestic product (GDP) at factor cost or alternatively, total value-added generated by labor and capital. Sectoral GDP is drawn directly the 2009 Supply-Use Table (SUT) (StatsSA 2010b). The original SUT distinguishes 62 industries, but the SAM aggregates these to 49 activities. Value-added is then divided into the returns to labor (compensation to employees) and capital (gross operating surplus including depreciation) using technical coefficients from the SUT. Aggregate value-added in the SAM differs slightly from the number that appeared in the Quarterly Bulletin (i.e., R2,150,203 billion) (SARB 2010). This is mainly due to differences caused by subsequent revisions to national accounts by the South African Reserve Bank.

Labor income is split across four educational groups: “primary” refers to workers with some or no primary schooling, i.e., grades 1-7; “middle” includes workers who have completed 10, “secondary” includes workers who have completed grade 12; and “tertiary” includes workers who have at least some post-secondary or higher education. Workers’ compensation is drawn from the 2009 Labor Force Survey (LFS) (StatsSA 2010a).

Table 2: 2009 Macro SAM for South Africa (Billions of Rands)

	Activities	Commod-ities	Factors	Enterprises	Households	Government	Investment	Rest of the World	Total
Activities		5,003							5,003
Commodities	2,826	427			1,463	518	456	599	6,290
Factors	2,145								2,145
Enterprises			706		43	119			869
Households			1,384	330		39		3	1,756
Government	32	219	52	169	210				683
Savings				331	40	-32		117	456
Rest of the World		640	2	39		38			719
Total	5,003	6,290	2,145	869	1,756	683	456	719	

Source: 2009 South Africa social accounting matrix.

ii. *(Commodities, Activities)… 2,826*

This is the value of intermediate inputs used in the production process (i.e., the "use" matrix). The technical coefficients are drawn directly from the 2009 SUT (StatsSA 2010b). These coefficients are the share of inputs used per value unit of output. The original SUT distinguishes 104 products, but the SAM aggregates these to 85 commodities.

iii. *(Government, Activities)… 32*

Producer taxes (negative if subsidies) are taken from the 2009 SUT (StatsSA 2010b).

iv. *(Activities, Commodities)… 5,003*

This is the value of total marketed output (i.e., the "supply" matrix). Since all output is assumed to be supplied to markets, this value is equivalent to gross output, where gross output is the sum of intermediate demand and GDP at factor cost. Each activity may produce more than one commodity, and conversely, each commodity may be produced by more than one activity. This information from drawn directly from the 2009 SUT (StatsSA 2010b).

v. *(Commodities, Commodities)… 427*

These are the transaction costs incurred in moving goods from producers to consumers, or from borders to consumers (for imports) or producers to borders (for exports). The transaction cost margins are drawn from the 2009 SUT (StatsSA 2010b).

vi. *(Government, Commodities)… 219*

This is equal to taxes on products less subsidies on products. While the macro SAM shows only a single row and column for government taxes, this cell entry consists of a distinct tax accounts for sales and import taxes. The 2009 SUT (StatsSA 2010b) reports net taxes on each product. This was used as a control total and the value of import tariffs was subtracted using information on tariff collection values provided by the South African Revenue Authority. Overall, aggregate net product taxes in the SAM differs from the number that appeared in the Quarterly Bulletin (i.e., R225,635 billion) (SARB 2010).

vii. *(Rest of world, Commodities)… 640*

The value of total imports of goods and services was taken from the 2009 SUT (StatsSA 2010b). Aggregate imports in the SAM differs from the number that appeared in the Quarterly Bulletin (i.e., R677,740 billion) (SARB 2010).

viii. *(Commodities, Households)… 1,463*

The payment from households to commodities is equal to household consumption of marketed production. The total level of private consumption of each commodity is based on the 2009 SUT (StatsSA 2010b). Total private consumption in the SAM differs from the number that appeared in the Quarterly Bulletin (i.e., R1,473,490 billion) (SARB 2010).

Households in the SAM are disaggregated by national per capita expenditure percentiles. This was based on information from the 2005 Income and Expenditure Survey (StatsSA 2006). Consumption shares for each commodity were used to disaggregate consumption spending across the various household groups. In total there are 14 representative household groups in the 2009 SAM, i.e., nine expenditure deciles with the top decile split into two percentile groups.

ix. *(Commodities, Government)… 518*

This is the level of government recurrent expenditures, which is drawn from the 2009 SUT (StatsSA 2010b). Total public consumption in the SAM differs from the number that appeared in the Quarterly Bulletin (i.e., R505,040 billion) (SARB 2010).

x. *(Commodities, Investment)… 456*

This is the value of gross capital formation, which is disaggregated in the 2009 SAM into total public and private investment, and changes in inventories or stocks. These more detailed investment demand vectors are taken from the 2009 SUT. The total value of gross capital formation in the SAM differs from the number that appeared in the Quarterly Bulletin (i.e., R467,878 billion) (SARB 2010).

xi. *(Commodities, Rest of world)… 599*

The value of total exports of goods and services was taken from the 2009 SUT (StatsSA 2010b). The total value of export demand in the SAM differs from the number that appeared in the Quarterly Bulletin (i.e., R657,113 billion) (SARB 2010).

xii. *(Government, Factors)… 52*

This is the value of the government's gross operating surplus, as reported in the South African Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) – see account 6786J. Since the government in the SAM is treated as a series of activities that produces government services (e.g., public administration, health and education), this is a payment from those activities (and other state enterprises) to the government.

xiii. *(Rest of world, Factors)… 2*

This is the compensation of non-residents working in South Africa less the compensation of South African residents working abroad. This information is reported in the South African Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see accounts 6207J and 6208J.

xiv. *(Enterprises, Factors)… 706*

Enterprises earn the returns to capital generated during the production process after they have paid factor taxes and repatriated profits. This is therefore the payment of gross operating surplus to financial and non-financial enterprises as reported in the South African Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see accounts 6706J and 6746J.

xv. *(Households, Factors)… 1,384*

Households directly receive labor incomes as well as some capital returns. The former is derived from the 2009 SUT (StatsSA 2010b) and differs slightly from the number that appeared in the Quarterly Bulletin (i.e., R706,785 billion) (SARB 2010). The latter is the payment of gross operating surplus/mixed income to households and is drawn from the South African Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see account 6826J. These factor incomes are distributed to different representative household groups based on incomes reported in the 2005 Income and Expenditure Survey (StatsSA 2006).

xvi. *(Enterprises, Households)… 43*

This is the interest on property income received and paid by households, which is reported in the South African Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see accounts 6828J and 6833J.

xvii. *(Enterprises, Government)… 119*

This is the interest on property income received and paid by government from domestic and foreign enterprises. This information is reported in the Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see accounts 6788J, 6792J, 6902J and 6905J.

xviii. *(Government, Enterprises)… 169*

This is current taxes on income and wealth paid by financial and non-financial enterprises to the government. This information is reported in the Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see accounts 6717J and 6758J.

xix. *(Households, Enterprises)… 330*

Enterprises pay indirect capital returns to households after they've saved, paid taxes and made other transfers to the government and rest of world. It is treated as a residual balancing item in the macro SAM and is distributed to representative households in SAM using information on non-labor factor incomes reported in the 2005 Income and Expenditure Survey (StatsSA 2006).

xx. *(Savings, Enterprises)… 331*

This is gross saving by financial and non-financial enterprises. This information is reported in the Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see accounts
6725J and 6765J.

xxi. *(Households, Government)… 39*

These are the social benefits paid by the government to households, e.g., state pensions, unemployment insurance, and child support grants. This information is reported in the Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see 6798J. These transfers are distributed to representative households in SAM using information state benefits received as reported in the 2005 Income and Expenditure Survey (StatsSA 2006).

xxii. *(Households, Rest of world)… 3*

This is net "miscellaneous current transfers" as reported in the Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see 6909J and 6912J.

xxiii. *(Government, Households)… 210*

This cell entry in the macro SAM consists of two parts. The first is a direct paymetnf rom households to the government and is equal to the difference between social contributions paid by household (i.e., account 6840J in the Quarterly Bulletin, SARB 2010) and social contributions received by financial enterprises (see account 6715J). The second component is direct taxes (PAYE) paid indirectly by households to the government via the direct tax account that appears in the 2009 SAM. This value of current taxes on income and wealth is drawn from the Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see account 6245J. As a proxy, it was distributed across representative households using information on educated labor incomes (grade 10+) as reported in the 2005 Income and Expenditure Survey (StatsSA 2006).

xxiv. *(Savings, Households)… 40*

This is the value of gross saving by households, as reported in the Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see account 6848J.

xxv. *(Savings, Government)… -32*

This is the value of gross saving by the government, as reported in the Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see account 6803J.

xxvi. *(Rest of world, Government)… 38*

These transfers from the government to the rest of the world consists of two components. The first is *net* current international co-operation, as reported in the Reserve Bank's Quarterly Bulletin of Statistics (SARB 2010) - see accounts 6908J and 6911J. The second component is net interest paid or received on property income – see accounts 6902J and 6905J.

xxvii. *(Savings, Rest of world)… 117*

This is the current external balance (balance on current account). Due to differences in import and export values in the 2009 SUT, the number appearing in the SAM differs from the number reported in the Quarterly Bulletin (R96,573 billion) (SARB 2010) - see account 6913J.

4. Balancing the prior SAM

The range of datasets used to construct the prior micro SAM implies that there will inevitably be imbalances (i.e., row and column totals are unequal). Cross-entropy econometrics is used to reconcile SAM accounts (see Robinson et al., 2001). This approach begins with the construction of the prior SAM, which as explained in the previous section, used a variety of data from a number of sources of varying quality. This prior SAM provided the initial 'best guess' for the estimation procedure. Additional information is then brought to bear, including knowledge about aggregate values from national accounts and technology coefficients. A balanced SAM was then estimated by minimizing the entropy 'distance' measure between the final SAM and the initial unbalanced prior SAM, taking into account of all additional information.

Balancing procedure for the SAM

The balancing procedure takes places in two stages. First, a very detailed national SAM was constructed using the supply-use table, national accounts, state budgets and balance of payments. At this stage, the SAM contains aggregate entries for factors and households. This aggregate national SAM was then balanced using cross-entropy.

After balancing the national SAM, it was then disaggregated across factors and households. Since the aggregate national SAM is balanced, this results in imbalances for the household accounts only. These household accounts were again balanced using cross-entropy, but holding all other non-household-related entries of the national SAM constant. Given the imbalances in the household survey between incomes and expenditures, the target household income/expenditure total for the final balanced SAM was the expenditure totals in the unbalanced prior SAM.

Cross-Entropy Estimation of the Balanced SAM

Table 8 presents the equations defining the SAM estimation procedure. Starting from an initial estimate of the SAM, additional information is imposed in the form of constraints on the estimation. Equation 1 specifies that row sums and corresponding column sums must be equal, which is the defining characteristic for a consistent set of SAM accounts. Equation 2 specifies that sub-accounts of the SAM must equal control totals, and that these totals are assumed to be measured with error (Equation 3). An example would be the estimate of GDP provided by national accounts, which is the total value of the Factor-Activity matrix in the prior SAM. The matrix G is an aggregator matrix, with entries equal to 0 or 1. The index k is general and can include individual cells, column/row sums, and any combination of cells such as macro aggregates. Equation 4 allows for the imposition of information about column coefficients in the SAM rather than cell values, also allowing for error (Equation 5).

Table 8: Cross-entropy SAM estimation equations

Index	
i, j	Row (i) and column (j) entries
k	Set of constraints
w	Set of weights
Symbol	
T_{ij}	SAM in values
$A_{ij}, \bar{A}_{ij}$	SAM in column coefficients
G_{kij}	Aggregator matrix for each constraint k
$\gamma_{ij}, \bar{\gamma}_{ij}$	Aggregate value for constraint k
e_k	Error on each constraint k
e_{ij}^A	Error on each cell coefficient
$W, \bar{W}$	Weights and prior on error term for each constraint k or cell coefficient i,j
$\bar{V}$	Error support set indexed over w for each constraint k or cell coefficient i,j
Equations	

$$\sum_i T_{ij} = \sum_j T_{ij} \tag{1}$$

$$\sum_i \sum_j G_{kij} \cdot T_{ij} = y_k \tag{2}$$

$$\gamma_k = \bar{\gamma}_k + e_k \tag{3}$$

$$A_{ij} = T_{ij} / \sum_i T_{ij} \quad \text{with} \quad \sum_i A_{ij} = 1 \forall i \tag{4}$$

$$A_{ij} = \bar{A}_{ij} + e_{ij}^A \quad \text{for some i and j} \tag{5}$$

$$e_k = \sum_w W_{kw} \cdot \bar{V}_{kw} \tag{6}$$

$$e_{ij}^A = \sum_w W_{ijw}^A \cdot \bar{V}_{ijw}^A \tag{7}$$

$$\sum_w W_{kw} = 1 \quad \text{with} \quad 0 \leq W_{kw} \leq 1 \tag{8}$$

$$\sum_w W_{ijw}^A = 1 \quad \text{with} \quad 0 \leq W_{ijw}^A \leq 1 \tag{9}$$

$$\min \left[\sum_k \sum_w W_{kw} \cdot (\ln W_{kw} - \ln \bar{W}_{kw}) + \sum_i \sum_j \sum_w W_{ijw}^A \cdot \left(\ln W_{ijw}^A - \ln \bar{W}_{ijw}^A \right) \right] \tag{10}$$

The error specification in Equations 2 and 3 describes the errors as a weighted sum of a specified ‘support set’ (the V parameters). The weights (W) are probabilities to be estimated, starting from

a prior on the standard error of measurement of aggregates of flows (Equation 8) or coefficients (Equation 9). The number of elements in the error support set (w) determines how many moments of the error distribution are estimated. The probability weights must be non-negative and sum to one (Equations 8 and 9). The objective function is the cross-entropy distance between the estimated probability weights and their prior for the errors in both coefficients and aggregates of SAM flows. It can be shown that this minimand is uniquely appropriate, and that using any other minimand introduces unwarranted assumptions (or information) about the errors.

Various constraints were imposed on the model according to the perceived reliability of the data. Certain values that appeared in the supply-use table and national accounts were maintained in order to remain consistent with the overall macro structure of the economy. The macroeconomic aggregates that were maintained in the micro-SAM include: total labor value-added; total capital value-added; household final demand; government spending; investment demand; exports; imports; government borrowing/saving; current account balance; sales taxes; import tariffs; direct taxes on enterprises; government transfers to enterprises; enterprise transfers to the rest of the world; enterprise transfers to government; household transfers to government; government transfers to the rest of the world; and household foreign transfers received. The same standard errors were applied to all representative household groups.

References

Breisinger, C., M. Thomas and J. Thurlow. 2009. *Social Accounting Matrices and Multiplier Analysis: An Introduction with Exercises*, Food Security in Practice Technical Guide 5, International Food Policy Research Institute, Washington D.C.

Pyatt, G. 1988. "A SAM Approach to Modeling," *Journal of Policy Modeling*, 10, 327-352.

Pyatt, G. and J. Round. 1985. *Social Accounting Matrices: A Basis for Planning*, World Bank, Washington, D.C.

Reinert, K. A., and D. W. Roland-Holst. 1997. "Social Accounting Matrices," in J. F. Francois, and K. A. Reinert (eds.) *Applied Methods for Trade Policy Analysis: A Handbook*, Cambridge University Press, New York.

Robinson, S., Cattaneo, A., and El-Said, M. 2001. "Updating and Estimating a Social Accounting Matrix Using Cross Entropy Methods," Economic Systems Research, 13(1), 47-64.

Robinson S. and D.W. Roland-Holst. 1988. "Macroeconomic Structure and Computable General Equilibrium Models," *Journal of Policy Modeling*, 10(3), 353-375.

SARB. 2010. "Quarterly Bulletin of Statistics: Release date 10 October 2010," Pretoria, South Africa: South African Reserve Bank.

StatsSA. 2006. "2005 Income and Expenditure Survey," Pretoria, South Africa: Statistics South Africa, Government of Republic of South Africa.

StatsSA. 2010a. "Quarterly Labour Force Survey: Quarter 3 2009," Pretoria, South Africa: Statistics South Africa, Government of Republic of South Africa.

StatsSA. 2010b. "2009 Supply-Use Table," Pretoria, South Africa: Statistics South Africa, Government of Republic of South Africa.