The Technology of Consumption and the SAM Approach

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ABSTRACT This paper develops a standard social accounting matrix (SAM) approach. The main emphasis is on the problem of householder's consumption. Within the SAM framework, a model, formally similar to the IO model, is proposed to construct the matrix of technology of consumption. Specifically, a number of conditions for perfect construction of modified SAM are formulated. On this basis a 23-sector SAM for Russia is constructed. The empirical results show the practical feasibility of the proposed approach.

KEYWORDS: Social accounting matrix, input-output model, technology of consumption.

1. Introduction

Thanks to the work of Pyatt and Thorbecke (1976), devoted a social accounting matrix (SAM) approach, it is recognized the importance of capturing the circular flow and organizing a macro-economic model around. A SAM method is the natural extension of an IO economics.

SAM provides a framework that covers the full circular flow of income between production, factors of production and institutions in the economy. In addition to the industry, final demand and value-added data, the SAM includes the distribution of income from primary factors to households, government and the foreign sector. What we propose here is an alternative, complementary way to compute gross domestic output multipliers and employment multipliers.

There are many studies based on SAM approach such as Reinert, Roland-Holst and Shiells (1993), Roberts (1995), Ruiz and Wolf (1996), Manresa, Sancho and Vegara (1998). Unfortunately, there are no any studies of dissagregated SAM based on Russian materials.

Section 2 contains an introduction to modified SAM approach, which based on Keynesian theory of multiplier and IO method. The offered model is based on the use of the special «consumption matrix». Some differences between SAM method and new approach are described.

The formal structure of new model is described in Section 3. We show how to construct a new conceptual framework.

The main empirical results are reported in Section 4, where Section 4.1 provides comparison between numerical results following both calculations: those derived from modified SAM approach with those of the standard implementation of the IO method. Section 4.2 contains the empirical analysis of employment multipliers.

Finally, Section 5 presents some concluding remarks.

2. Technology of Consumption

One of the main differences the SAM approach from standard IO method is distribution of income from primary factors to several groups of households. Pyatt and Thorbecke (1976) suppose that there are three criteria on which a household classification should be based: location; sociological considerations and the wealth. They consider three groups of households: urban, rural and estate. This approach gives an opportunity to consider household's consumption as matrix, not a vector as in standard Leontiew's framework.

Define as **C = (Cir)** matrix of household's consumption, where **i** is an index of industry, which produced commodity, **r** is an index of household's group. This matrix describes a structure of household's consumption. Let us name this matrix as «consumption matrix».

In our approach we offer new household classification based on industry, in which household receive income (salary, profit, percent and so on). So the consumption matrix may be defined as a «technology of consumption» **C = (Cij)**, where **j** is index of industry which uses production of industry **i**. The structure of the matrix **C** is analogous with the structure of the technological matrix **A**, so define coefficient $\mathbf{c_{ij}} = \mathbf{C_{ij}/X_j}$ as direct consumption coefficient.

It is easy to construct the matrix **C,** if we suppose:

1. all employed peoples receive income in one branch;
2. all members of household work in one branch;
3. households receive income from primary factors, but not receive any transfers (pensions, relief and so on)

Consider, for example, economics, which consists from 2 branches - agriculture and manufacturing. Having this assumption, we may consider, for example, coefficients $\mathbf{C_{12}}$ as the total sum of manufacturing's consumption of the workers (households) which employed (receive income) in agriculture.

The next stage of our analysis is to adopt real data to new approach. Let us consider a household which members have different sources of income. For example, first member works in both branches and receives 1250 dollars in agriculture and 1750 dollars in manufacturing. The second member receives 2000 dollars from manufacturing. The total income of this family is 5000 dollars. Suppose that for this household a structure of expenditures (technology of consumption) is follows: 30 % of total income is expenditures for agriculture products, 50 % - expenditures for manufacturing productions, 20 % are savings and taxes. The total income received from manufacturing is 3750 dollars and 3000 dollars from this sum used for consumption. The income received from agriculture is 1250 dollars and 1000 dollars from this sum used for consumption. So we may construct matrix **MC** for this household using it's technology of consumption: $\mathbf{C_{11}}$ = 375**;** $\mathbf{C_{21}}$ = 625; $\mathbf{C_{12}}$ = 1125**;** $\mathbf{C_{22}}$ = 1875. Using this procedure to another households we obtain the total matrix **C** by addition all separate matrixes of household's consumption **C**.

3. The Formal Structure of the Model

Let us start by considering a standard IO model, which can be written in scalar form as follows:

$$\bar{\mathbf{A}} + \mathbf{W} = \mathbf{X} = \bar{\mathbf{A}} + \mathbf{Y}, \qquad (1)$$

where $\bar{\mathbf{A}}$ is a total sum of intermediate products, **W** is a total sum of added value (the total income), **Y** is a total final demand, **X** is a gross output. The left side of the equation (1) is a total supply and the right part shows a total demand.

The Leontiew's inverse matrix $\mathbf{(E\text{-}A)^{-1}}$ is the matrix multiplier of gross output, where **A** is an (n*n) matrix of direct input coefficients. This multiplier shows the total growth of gross output, connected with the increasing of total final demand.

The standard Keynesian equation of general equilibrium can be described as follows:

$$\mathbf{C + S + T = Y = C + I + G + NE}, \qquad (2)$$

where **C, S, T, I, G, NE** are the scalar indexes of household consumption, household saving, total sum of taxes, total sum of investments, government expenditures and net export. The left side of the equation (2) is a total supply and the right part shows a total demand.

The Keynesian multiplier **k** can be described as follows:

$$\mathbf{k = 1/(1\text{-}c)}, \qquad (3)$$

where $\mathbf{c = \Delta C/\Delta Y}$ is a marginal propensity to consume, $\mathbf{\Delta C}$ is a growth of household consumption, $\mathbf{\Delta Y}$ is a growth of national income (total final demand).

It is obviously that both multipliers have some shortcomings. The matrix $\mathbf{(E\text{-}A)^{-1}}$ not shows the growth of the total income, which is the most important macroeconomics index. So this multiplier can not be used in calculations of income's changes. The Keynesian multiplier **k** is a scalar multiplier, so it is not shows a growth of national income, connected with the growth of total final demand in separate industries.

Let us suppose that the total income **W** is equal a sum of expenditures: the household consumption, the household saving and the total sum of taxes. So we can consider the following equation of general equilibrium based on both equations (1) and (2):

$$\overline{\mathbf{A}} + \mathbf{C} + \mathbf{S} + \mathbf{T} = \mathbf{X} = \overline{\mathbf{A}} + \mathbf{C} + \mathbf{I} + \mathbf{G}. \tag{4}$$

The matrix form of equation (4) is described as follows:

$$\sum_i \mathbf{A}_{ij} + \sum_i \mathbf{C}_{ij} + \mathbf{S}_j + \mathbf{T}_j = \sum_j \mathbf{A}_{ij} + \sum_j \mathbf{C}_{ij} + \mathbf{I}_i + \mathbf{G}_i, \qquad \text{if } \mathbf{i = j} \tag{5}$$

The left side of the equation (5) is a total supply of industry **j** and the right part shows a total demand.

It is not differences for producer - who is a consumer of the product - enterprise or household. For example, the sugar's plant sells sugar to the confection's factory and to member of household, which is employed in this factory. If we sum productive and non-productive consumption of some commodities, we may receive the total value of expenditures of this product $\mathbf{D_{ij}=A_{ij}+C_{ij}}$ (sugar and so on). So we consider both household consumption and productive expenditures as endogenous parameters.

Let us introduce new form of matrix multiplier **M**: (see Dondokov, 2000 a)

$$\mathbf{M = (E-D)^{-1}}, \tag{6}$$

where $\mathbf{D=(d_{ij}), d_{ij}=D_{ij}/X_j}$.

This multiplier gives an opportunity to calculate whole multiplier effects. For example, if aircraft plant will produce and sell additional airplane for export, its workers will receive additional income, so they will buy more commodities and so on. The standard IO model can not gives this opportunity.

Let us consider open economics, so the equation of general equilibrium may be written as system of two equations:

$$\sum_j \mathbf{A}_{dij} + \sum_j \mathbf{A}_{zij} + \sum_j \mathbf{C}_{dij} + \sum_j \mathbf{C}_{zij} + \mathbf{G}_i + \mathbf{I}_i + (\mathbf{V}_i - \mathbf{M}_i) = \mathbf{X}_i, \tag{7}$$

$$\sum_i \mathbf{A}_{dij} + \sum_i \mathbf{A}_{zij} + \sum_i \mathbf{C}_{dij} + \sum_i \mathbf{C}_{zij} + \mathbf{S}_j + \mathbf{T}_j = \mathbf{X}_j, \tag{8}$$

where $\mathbf{V_i}$ is an export of industry **i** and $\mathbf{M_i}$ is an import of industry **i**, coefficients $\mathbf{A_{dij}}$ and $\mathbf{A_{zij}}$ are domestic and import direct inputs, $\mathbf{C_{dij}}$ and $\mathbf{C_{zij}}$ are domestic and import direct consumption's expenditures. It is obviously that the sum of domestic and import indexes is equal the total index:

$$\mathbf{A_{dij} + A_{zij} = A_{ij}}. \tag{9}$$

$$\mathbf{C_{dij} + C_{zij} = C_{ij}}. \tag{10}$$

Define $\mathbf{A_{dij}+C_{dij}} = \mathbf{D_{rij}}$, matrix $\mathbf{A_d} = (\mathbf{a_{dij}})$ is the domestic direct input matrix, $\mathbf{C_d} = (\mathbf{c_{dij}})$ is the domestic direct consumption matrix, where $\mathbf{a_{dij}=A_{dij}/X_j}$, $\mathbf{c_{dij}=C_{dij}/X_j}$. Let us name matrix $\mathbf{D} = (\mathbf{D_{rij}})$ as **matrix of total inputs (matrix of total expenditures)**.

The matrix multiplier $\mathbf{M_r}$ is described as follows:

$$\mathbf{M_r = (E\text{-}D_r)^{-1} = (E\text{-}(A_d+C_d))^{-1}}. \quad (11)$$

where $\mathbf{D_r = (d_{rij})}$, $\mathbf{d_{ij}=D_{rij}/X_j}$

Let us name the multiplier $\mathbf{M_r}$ as **multiplier of total expenditures**. It shows the growth of gross domestic product connected with the growth of exogenous parameters (total sum of investments, government expenditures and net export).

At the next stage we calculate coefficients $\mathbf{W_j}$. They equal the shares of gross value added in gross output $\mathbf{X_j}$:

$$\mathbf{W_j = 1\text{-}\sum_i a_{ij}}. \quad (12)$$

Let us introduce vector $\mathbf{W = (W_j)}$. So the multiplier of income **К** can be written as:

$$\mathbf{К = W^*M_r}. \quad (13)$$

This multiplier **K** gives answer to the question: how to calculate growth of income (gross domestic product - GDP) connected with the growth of exogenous parameters.

This multiplier is a good tool in analysis of import leakage. The standard SAM can not provides this opportunity to evaluate this kind of leakage - total industry's leakage. For example, if sugar in our example is import product, then both confection's factory (coefficient $\mathbf{a_{zij}}$) and household (coefficient $\mathbf{c_{zij}}$), not only enterprise, contribute to import's growth.

4. An Empirical Comparison

The main databases for this study were provided by the Institute for Macro-economics Research of Ministry of Economics of Russian Federation. They comprise two 23-sectors IO tables for 1995: standard table and import table. Unfortunately, there is not adequate information about household' consumption in sectors, so we suppose that the technology of consumption is uniform for all sectors (industries).

4.1 The Multipliers of Gross Output and Income

Let us begin with statistics on multipliers by industry in 1995 (Table 1). The detailed analysis of obtained results is written in (Dondokov, 2000 b).

The first column in Table 1 shows what the multipliers would be if there were complete import substitution, i.e. no imported intermediate inputs. This is given by:

$\mathbf{M_1 = (E\text{-}A)^{-1}}$

There is considerable variation among sectors, from a high of 2.46 roubles per rouble of iron and steel to a low of 1.59 roubles per rouble in commercial services. The scalar multiplier (all sector multiplier) is equal 2.11 roubles per rouble of total final demand.

Table 1. Total (direct and indirect) multipliers, Russia,1995

Sector number and name	Multipliers			Per cent difference		Income multiplier **M4**
	Classic (**M1**)	Domestic (**M2**)	Total (**M3**)	**M3-M1**	**M3-M2**	
1 Electricity	2.14	2.04	2.98	39.2	46.0	1.39
2 Petroleum and natural gas	2.26	2.18	3.20	41.5	46.8	1.43
3. Coal	2.29	2.17	3.39	48.0	56.2	1.50
4 Other mining	2.14	2.05	3.35	56.5	63.4	1.56
5 Iron and Steel	2.46	2.23	3.32	34.9	48.8	1.41
6 Non-ferrous metals	2.23	2.02	3.13	40.3	54.9	1.42
7 Chemical	2.38	2.08	3.09	29.8	48.5	1.33
8 Machinery	2.16	1.85	2.83	31.0	52.9	1.31
9 Wood products	2.20	2.06	3.14	42.7	52.4	1.43
10 Construction materials	2.35	2.21	3.29	40.0	48.8	1.44
11 Closing and leather	2.30	1.32	2.02	-12.2	53.0	0.89
12 Food industry	2.32	1.83	2.71	16.8	48.1	1.18
13 Other manufactures	2.17	1.90	3.01	38.7	58.4	1.39
14 Construction	1.93	1.78	2.88	49.2	61.8	1.44
15 Agriculture	2.09	1.91	2.98	42.5	56.0	1.41
16 Productive transport and communication	1.68	1.60	2.58	53.5	61.2	1.41
17 Non-productive transport and communication	2.09	1.97	3.34	59.8	69.5	1.57
18 Commercial services	1.59	1.51	2.80	76.1	85.4	1.55
19 Other productive services	1.67	1.59	2.95	76.6	85.6	1.59
20 Education, medicine and culture	1.90	1.79	2.84	49.4	58.6	1.43
21 Dwelling services	2.24	2.14	3.32	48.2	36.4	1.45
22 Government and finance	1.89	1.74	2.92	54.4	67.8	1.47
23 Science	2.03	1.91	2.65	30.5	38.7	1.29
All sectors	2.11	1.90	3.04	44.0	60.0	1.43

The second column in Table 1 shows the multipliers $\mathbf{M_2}$, based on the domestic coefficient matrix, i.e.

$\mathbf{M_2 = (E\text{-}A_d)^{-1}}$

A highest value of multipliers is obtained in iron and steel too – 2.23 roubles per rouble and a lowest in closing and leather – 1.32 roubles of gross output's growth per rouble of total final demand's growth. The scalar multiplier (all sector multiplier) is equal 1.90 roubles per rouble of total final demand.

Column three in Table 1 shows the multiplier of total expenditures $\mathbf{M_3}$, based on the matrix of total inputs, i.e.

$\mathbf{M_3 = (E\text{-}(A_d\text{+}C_d))^{-1}}$

A highest value of multipliers is obtained in coal industry – 3.39 roubles per rouble and a lowest in closing and leather – 2.02 roubles of gross output's growth per rouble of exogenous final demand's growth. The all sector's multiplier is equal 3.04 roubles per rouble of demand's growth.

The column four in Table 1 shows the percentage difference between multipliers $\mathbf{M_1}$ and $\mathbf{M_3}$. There is considerable variation among sectors, from a high of 76.6 % in other productive services to a low of –12.2 % for the closing and leather. It means that in the closing and leather industry most of intermediate and non-intermediate inputs are imported.

The column five in Table 1 shows the percentage difference between $\mathbf{M_2}$ and $\mathbf{M_3}$. A high value indicates the existence of considerable import leakage in use of non-intermediate inputs. Here, too, there is considerable variation among sectors, from a high of 85.6 % in other productive services (most of non-intermediate inputs are imported) to a low of 36.4 % for the dwelling services (most of non-intermediate inputs are produced locally).

The sixth column in Table 1 shows the multiplier of income $\mathbf{M_4}$. This is given by

$\mathbf{M_4 = W^*M_3}$

A highest value of multipliers is obtained in other productive services - 1.59 roubles per rouble and a lowest in closing and leather – 0.89 roubles of income's (gross domestic product's) growth per rouble of exogenous final demand's growth. The all sector's multiplier is equal 1.43 roubles per rouble of demand's growth. So, it is obviously that the closing and leather industry in Russia in 1995 provided worth economic results because of highest share of total import leakage.

4.2 The Employment Multipliers

Define

L = 10-order vector of total employment by industry

l = 10-order vector of labor coefficients, $l_j = L_j/X_j$

Let us begin with statistics on employment multipliers by industry in 1995 (Table 2).

The first column in Table 2 shows what the employment multipliers would be if there were complete import substitution, i.e. no imported intermediate inputs. This is given by:

$$\mathbf{T_1 = l(E-A)^{-1}}$$

There is considerable variation among sectors, from a high of 88 employees per million roubles in other productive services to a low of 23 employees per million roubles in commercial services. The all sector's multiplier is equal 40 employees per million roubles.

The second column in Table 2 shows the employment multipliers, based on the on the domestic coefficient matrix, i.e.

$$\mathbf{T_2 = l(E-A_d)^{-1}}$$

A highest value of multipliers is obtained in education - 81 employees per million roubles and lowest value is in commercial services - 21 employees per million. The all sector's multiplier is equal 36 employees per million roubles.

The third column in Table 2 shows the employment multipliers, based on the on the domestic coefficient matrix, i.e.

$$\mathbf{T_3 = l(E-(A_d+C_d))^{-1}}$$

Table 2 Employment Multipliers, 1995 (employees per million roubles)

Sectors	Employment multipliers			Per cent difference	
	T1	**T2**	**T3**	**T1-T2**	**T3-T2**
Industry	29.0	27.9	38.5	4.08	38.0
Construction	37.5	34.5	52.7	8.69	52.7
Agriculture	70.2	67.2	85.5	4.56	27.2
Transport and communication	29.3	27.0	49.9	8.81	84.8
Commercial services	23.8	21.8	44.9	9.04	105.9
Other productive services	88.2	73.3	110.4	20.39	50.6
Education	86.5	81.7	102.6	5.88	25.6
Dwelling services	46.8	43.4	61.4	8.02	41.4
Government and finance	30.1	26.0	47.6	16.04	83.0
Science	82.2	78.8	91.3	4.42	16.0
All sectors	40.5	36.5	58.4	11.28	60.0

Here, too, there is considerable variation among sectors, from a high of 110 employees per million roubles in other productive services to a low of 38 employees per million roubles in industry. We may see that accordingly our approach industry provided lower employment than other sectors because of highest share of total import leakage. The all sector's multiplier is equal 58 employees per million roubles.

The column four in Table 2 shows the percentage difference between $\mathbf{T_1}$ and $\mathbf{T_2}$. A high value indicates the existence of considerable import leakage in use intermediate inputs. Here, too, there is considerable variation among sectors, from a high of 20.39 % in other productive services to a low of 4.08 % for industry. The all sector's difference is equal 11.28 %.

The column five in Table 2 shows the percentage difference between $\mathbf{T_3}$ and $\mathbf{T_2}$. A highest difference – 105.9 % is obtained in commercial services and the lowest value is in science – 16.0 %. The all sector's difference is equal 60.0 %.

4. Concluding Remarks

The new approach can generally be interpreted as an integration of Keynesian elements into Leontiew's framework. While the SAM approach develops a disaggregated and balanced view of the circular flow of income, our method is concentrate on household's consumption. If we use sector's classification of households, we may easy insert our model to SAM model.

5. References

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