14. THE INPUT-OUTPUT MODELING APPROACH TO THE NATIONAL ECONOMY

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Abstract

The paper presents the conceptual and analytical framework of the Input-Output approach to the Romanian Economy Macromodel. The model uses annual Input-Output (I-O) tables, behavioral analysis and support estimation equations for technical coefficients, macro indicators and other variables.

The I-O Model is based on the Romanian I-O tables and the methodology developed by Wassily Leontief (Nobel laureate in Economics, 1973). The model databases uses the 1989-2009 I-O tables and data series provided by the National Institute of Statistics for 105 branches of the economy, which are aggregated into seven sectors.

The paper deals with the integration of other I-O sub-models needed to address the economy as a whole into the original model, in the interest of the current development of the Romanian economy.

The model describes the structure and the potential of the Romanian economy and relies on the experience accumulated by the author in participating in the "Dobrescu macromodels" initiatives, the postdoctoral studies and analysis of input-output technical coefficients behavior or other studies based on I-O analysis.

Keyword: input-output, modeling, structural changes, coefficients, driving effect

JEL Classification: C5, E2, E6, H6

1. Introduction

In the context of the transition to the market economy and current economic crisis, in order to assume the targets of 2020 Agenda, Romania is at a turning point as regards the development paradigm and the economic and social sustainability.

For the Romanian economy, the economic modeling assumption is indispensable for a harmonious development.

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On the other hand, the EC proposes that the budget of each Member State is capped at 2.5% of GDP in the 2014-2020 financial period instead of 3.8% of GDP in the current financial period. For Romania, this means a reduction of available funds and is not at this moment a favorable decision given that it is a Member State with significant development gaps.

In this context, we believe that the identification of economic sectors of national interest is needed more than ever in order to modernize the Romanian economy using the European structural and cohesion funds, to establish the priority axes for allocating the funds and to negotiate with the EU the sectoral structure of the operational programs. Romania has to rediscover the sectors that have competitive and comparative advantages.

Thus, the objective of input-output modeling is to identify exactly the economic sectors of national interest in order to modernize the Romanian economy using own or European structural and cohesion funds. To achieve this goal, we consider the 'input-output' modeling as the optimal approach to investigate the economy-wide effects of any economic decision, as well as its effects on the aggregate sectors or branches.

The model is structured into several sub-models. Of the many issues associated with the large and complex topic of this research, several were approached, as follows:

- Issues related to the methodology of I-O tables as part of the National System of Accounts.

- The content and implementation stages of aggregate I-O tables required by the model, analytical valences of input-output structure and the type of economic information used in the proposed model.

- Structural characteristics of the Romanian economy, the main components of GDP, evolution of the main economic sectors.

- Competitiveness of the national economy, general considerations, specific rates, labor productivity as a dominant indicator.

The paper begins with the presentation of the main theoretical and methodological assumptions of the conceptual approach of I-O models. It continues with the presentation of arguments to support the idea that the input-output model offers unique attributes in the case of transition economies in crisis, which need a development strategy.

The paper concludes that the approached modeling offers a broad coverage of the macroeconomic behavior.

2. The Data and Methodology in I-O Modeling

In order to identify the economic sectors of national interest with the view to modernize the Romanian economy, the general equilibrium model allows researchers to examine the structural features of the national economy. However, in order to examine the structural changes, the structure and competitiveness of the national economy branches, the option for the current research was the use of a full input-output model.

The input-output analysis, developed by W. Leontief, was considered one of the major contributions to economics in the 20^{th} century. The model of analysis is mostly identified with the work of Wassily Leontief (1906-1999), who was awarded Nobel Prize in Economics in 1973 for his pioneering work in the area. In Romania, Prof. Emilian Dobrescu paid special attention to both the methodology and the related studies in the actual models developed for the National Prognosis Commission in 2005 and 2012.

Noteworthy are the visit made by Leontief in Romania in 1968, the translation of his book into Romanian and the academic exchanges conducted by Prof. Dobrescu and others with scholars from the USA in the 1970s, followed by the implementation of the first input-output tables in Romania.

The input-output model allows the estimation of the cumulative impact of various components of final demand on the productive sector. Also, the model can find resolution for a very complex theoretical and practical problem, namely the interdependencies between the sectoral structures within the national economy. In addition, the structural economic models try to quantify, using coefficients, the intensity of flows between the branches of national economy, and to catch the trend of the economic structure changes.

The Input-Output model uses the 1989-2009 data series of the I-O tables published in the national statistics, by 105 industries, and operated in an aggregation into seven sectors. Since the input-output tables are defined yearly, the model contains only annual macro indicators. All amounts are expressed in denominated local currency (RON). Processing data for modeling consists in operating with the following types of variables:

- Macroindicators[2] and weights (shares of sectors in the total sector);
- Technical coefficients, coefficients of direct changes;
- Inverse coefficients;
- Supply and demand multipliers - they facilitate analysis and forecasting, measure the total effect or impact of an increase in demand or supply.

The basic equation of the model has a matrix form X = AX + Y, where Production is represented by the sum of Intermediary consumption (AX) and Final demand (Y). By algebraic transformation we obtain: (I – A) X = Y, where I is the unit matrix and A, the coefficients matrix. We can estimate the production vector X through ‘Y multipliers’, as follows: $X = (I - A)^{-1} Y$, where $(I - A)^{-1}$ is the inverse matrix of (I – A) matrix. The condition to solve the system is that the determinant of the matrix is ‘not to be zero’ and, implicitly, that the multiplier has real values, so the system can be solved.

The structure of the input-output tables has been incorporated into national accounting system in many developed countries, and as a form of measurement of the GDP. In addition to the study of the structure of the national economies, the input-output model was used to study the economies and as a tool for national and regional economic planning.

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[2] Production, import, export, taxes, wages, gross capital formation, gross value added, final consumption, final resources, intermediate consumption, change in inventories, etc.

3. Features that Make the Input-Output Model Unique

Based on the fact that there are several elements that ensure the robustness, coherence and consistency of the I-O model, the paper concludes that the results confirm the benefits of using the I-O modeling in designing the macroeconomic model of the Romanian economy.

The utility of the input-output model for the Romanian economy can be summarized by some unique attributes:

1 - Provides a real picture of the entire economy;
2 - Illustrates the structural changes and competitiveness of all branches;
3 - Illustrates the flows and balances between branches, inputs and outputs;
4 - Offers different aggregation capabilities and criteria of industries in sectors;
5 - Allows direct GDP calculation, forecast and projections of economic policies;
6 - Permits simultaneous forecasting at macro indicator and branch level;
7 - Offers modeling and economic research capabilities of economic policies.

4. The Data Structure Used in the Input-Output Model

Concerning the data, we started from input-output tables published annually by the National Institute of Statistics. All input-output tables are available at current prices. To make the estimates more relevant in terms of macroeconomic analysis, the 105 branches were aggregated into seven sectors deemed representative of the configuration of the Romanian economy. Table 1 explains the correspondence of the initial classification (105 branches) with the new aggregated classification (seven sectors).

Table 1

The aggregated sectoral structure

Sector	Sector name	Branch codes of the classification based on 105 branches included in the aggregated sector
1	Agriculture, forestry and fishing	1…6
2	Mining, Energy production	7 …17, 35..37, 79…82
3	Other industry sectors, Manufacturing	18...34, 38... 78,
4	Constructions	83
5	Transports, Post, Telecommunications	87…92, 94…95
6	Trade and business services, Tourism	84…86, 93, 96-101, 105, 106
7	Public services	102, 103, 104

Source: Author's aggregation scheme.

The proposed macromodel addresses the growing need to have the macroeconomic analysis and rapid forecasting capacity that is adaptable to specific sectoral and regional requirements and that allows to anticipate, simulate and define appropriate response to major changes. All data and macro indicators are used in a seven sectors aggregation.

The development of the proposed model has also required the development of innovative elements, consisting of:

- the definition and exemplification of a proposal for a methodological framework for the development of a model based on the input-output analysis and tables,

- the building of the needed data base, of the aggregation procedures and of the information system starting from the coding of 105 branches, and their subsequent aggregation into the seven sectors, the adjacent calculations and analysis as required by the I-O analysis, the calculation and forecasting of coefficients and macro indicators,

- the shaping of a framework for economic modeling and the care to ensure its further expansion capacity.

5. Estimating the Variables

Methodologies based on I-O tables, the information technology used in modeling and prospective approaches, the computation, analysis of the evolution and use of coefficients, estimates for seven economic sectors, and relationships with macroeconomic sub-models are the main activities related to the model development.

According the I-O analysis, the technical coefficients, but also the main macro indicators, are estimated trough econometric equations used for simulations.

The inverse matrix $(I - A)^{-1}$ expresses the interdependencies among the sectors of the economy – not only direct as indicated by the coefficients of A matrix.

The estimation of coefficients through the frequent utilization of RAS procedure in applied economics comes from the need to update the technical coefficients. Such an operation is essential for macro models which incorporate input-output matrices and was extensively treated in Dobrescu E., Gaftea V., *On the accuracy of RAS method in an emergent economy.*

The analysis was carried out at different levels of aggregation, starting from 105 NACE branches (the largest nomenclature), continuing with the synthetic tables for seven sectors, complemented by data annexes, IT support, forecast data and simulations.

The production function and the study of its behavior alongside a "Labor force" module of the I-O, the study of an "Energy and Environment" module, as well as the "Regional" and "Global influences on economic framework" models, have been considered as research topics as well, for analysis and implementation in a single model.

5.1 Connection with Macroeconomic Sub-Models

The basic model structure of the necessary sub-models can be defined in terms of influence and role of the main factors, capital, labor, energy and raw-material resources. These factors are known as "KLEM" (Capital, Labor, Energy, Materials) and determine the priority economic changes.

The production function can be defined as a function of “KLEM” factors. Investment, household final consumption, domestic demand for goods and services and export demand, labor supply, the influence of government through taxes and investments, economic surplus or deficit on the existing prices, are elements that contribute to a general equilibrium in the model.

The main extensions needed to be developed as sub-models were decided for:

a. production function,

b. labor force;

c. energy and the environment,

d. regional and global impact with the influence of 'rest of the world'.

Considering this main policy analysis, the central model provides coverage of economic and functional requirements for a minimum national model. We detail the theoretical and practical approach for several sub-models, also based on data structures of the 'input-output' tables.

5.2 Examination of Sectoral Production

In the terms of specific economic behavior of the Romanian economy and aggregation used in accordance with observations for the structural and competitiveness analysis, the correlation between sector’s production, imports, exports and GDP evolution was examined to determine and study the behavior of the proposed sectoral ‘production function’. The correlation matrix was calculated in Excel, year by year for the previous data series for each year.

Results were estimated and exemplified by the production function:

$Q=f(Q(-1)*(\%GDP) + Sx/N^2 + (Q(-1)-Q(-2))$, where: Q is a function depending on previous values, GDP growth index and correlation factor Sx (x represents the 1 to 7 sectors) divided by number of variable N of 2nd power.

Table 2

Average errors of the production function (Q) estimations

	~2007	~2008	~2009	~2010	~2011	~2012
Q	1.033036	1.00217	1.06621	0.96005	1.032263	1.0985246

Source: Author’s estimation.

Table 3 presents the correlation result for one year between the 10 series of variables (seven sectors’ production, import, export, GDP). Year by year behavioral tests and error analysis were performed to the real values for the data series of production values regarding the seven sectors after 2000.

Table 3

Correlation matrix for the calculation of the production function

	S1	*S2*	*S3*	*S4*	*S5*	*S6*	*S7*	*M*	*X*	GDP
S1	1	0.86	0.89	0.9	0.85	0.93	0.95	0.94	0.93	0.94
S2	0.8635	1	0.71	0.87	0.99	0.91	0.91	0.82	0.77	0.88
S3	0.8927	0.71	1	0.93	0.71	0.93	0.93	0.95	0.99	0.96
S4	0.902	0.87	0.93	1	0.88	0.99	0.98	0.95	0.95	0.99
S5	0.8533	0.99	0.71	0.88	1	0.92	0.91	0.84	0.77	0.88
S6	0.9295	0.91	0.93	0.99	0.92	1	0.99	0.97	0.95	0.99
S7	0.9496	0.91	0.93	0.98	0.91	0.99	1	0.97	0.96	1
M	0.9392	0.82	0.95	0.95	0.84	0.97	0.97	1	0.98	0.98
X	0.9295	0.77	0.99	0.95	0.77	0.95	0.96	0.98	1	0.97
GDP	0.9419	0.88	0.96	0.99	0.88	0.99	1	0.98	0.97	1

Source: Author's estimation.

The strong correlation and small deviations obtained in annual estimation considering the high degree of variation of economic growth during this economic period, characterized by strong crisis after 2008, were considered as acceptable for testing and estimating the proposed production function.

5.3 Approach to Labor Force, Energy and the Environment, Regionally and Globally

a) I-O tables can be used, along with additional statistical data, to calculate the employment in a particular sector. The analysis is based on classical solution relationships obtained by solving the I-O systems of equations:

$X * (I-A) = Y$; $X = (I-A)^{-1} * Y = B * Y$; where: $B = (I-A)^{-1}$

X is related to final demand Y trough the coefficient matrix B (inverse Leontief matrix).

To convert production figures into employment numbers, we need a vector of employment per unit of production. It is usually measured in units of labor with permanent employment and remuneration represented by W-wages (macro indicator of I-O Tables).

We can finally obtain E - employment in a relation:

$E_j = \Sigma_i W_i B_{ij}$; where uniform increase in final demand for sector j will generate direct employment Ej and direct and indirect effects in remaining sectors.

The input-output tables can be used to answer the two questions of the I-O analysis:

1. How many jobs are now covered by a particular sector?

2. How many additional jobs would be created if demand and the production sector increased by a certain amount? Here is an advantage of using I-O methodology in the labor sub-model.

The adopted solution brings an "original element" in the practice, especially the ability to identify indirect effects, the impact of employment measures in other sectors of economy.

b) In the I-O modeling approach, the intermediate consumption can be determined in natural units (physical). If Q_i is in this case the production of sector i and q_{ij} - part of it taken by sector j, the link between the two modes of expression is made through the price system:

$x_{ij} = p_i q_{ij}$ and $X_j = p_j Q_j$ and between,

direct and expenditure coefficients $a_{ij} = x_{ij} / X_j$ and direct consumption coefficients

$$\alpha_{ij} = q_{ij} / Q_j,$$

the relationship is: $a_{ij} = p_i q_{ij} / p_j Q_j = \alpha_{ij} p_i / p_j.$

The relationship can be formulated at the matrix level. The solution presented is necessary because the energy sub-model is necessary to build the I-O table in production units, kWh or toe/toe (tones oil equivalent) and the emissions associated with this table.

c) GDP is an overall macro indicator of the national economy, but in practice ratings at administrative units level are necessary. Regional accounts are the version that complies with the ESA 1995 methodology. In Romania, Regional Gross Domestic Product (RGDP) is calculated for the four macro regions divided into eight development regions and one extra-region. We present an aggregation for the regional model specific to I-O analysis.

Table 4

Romanian regional I-O modeling structure - price in millions lei – year 2009

Macro regions			MR 1		MR 2		MR 3		MR 4		UF	**GDP**	EXP
	Reg.		*N-W*	*C*	*N-E*	*S-E*	*B-IF*	*S*	*S-W*	*W*		***extern***	
			1	2	3	4	5	6	7	8		439.3	
MR 1	N-W	1	0.1474	0.149	0.1555	0.152	0.0629	0.1415	0.207	0.168	4500	57900	2640
	C	2	0.1638	0.165	0.1728	0.169	0.0699	0.1572	0.23	0.187	5000	57101	5500
MR 2	N-E	3	0.0865	0.087	0.0912	0.089	0.0369	0.083	0.121	0.099	2640	54408	5500
	S-E	4	0.1802	0.182	0.19	0.186	0.0769	0.1729	0.253	0.205	5500	52706	3000
MR 3	B-IF	5	0.2673	0.27	0.2819	0.276	0.1141	0.2566	0.375	0.305	8160	124289	6400
	S	6	0.1802	0.182	0.19	0.186	0.0769	0.1729	0.253	0.205	5500	65142	4500
MR 4	S-W	7	0.0983	0.099	0.1037	0.102	0.0419	0.0943	0.138	0.112	3000	39954	5000
	W	8	0.2096	0.212	0.2211	0.217	0.0895	0.2012	0.294	0.239	6400	49200	8160
	RES		30527	30216	28942	29541	71534	31802	21762	26773		501139	40700
	GDP		57900	57101	54408	52706	124289	65142	39954	49200			
	GVA		52180	51063	48971	48050	119334	57688	35974	44873			
	IMP		6700	7000	2950	6500	30640	7000	2200	7000			

Source: Author's computations, based on the data of the Statistical Yearbook of Romania.

The names of the regions are encoded by the cardinal points abbreviation, and the other indicators are: RES = resources UF = final uses, IMP/EXP= import/export, GVA= gross value added, GDP economy.

Through its practical content, the increase in experience in modeling the capacity of the Romanian economy, the identification of niche sectors and the initiation of measures to protect and encourage domestic production as the most stringent requirements, the I-O model offers in a unique modeling framework, an actual or forecasted picture of the economy.

6. Recommendations for Policy Makers

The purpose of the model is not only to be used for making own forecasts, but for checking the consistency of the policies, the forecast scenarios and the structural and competitiveness changes.

For the 2014 – 2020 planning period, the European Commission has decided that the cohesion policy remains the essential component of the future financial packages and it emphasizes its primary role to support the European 2020 Strategy.

For Romania, structural and cohesion funds represent the most important potential investment in the economy and, therefore, the greatest source of impact on the future economic growth. The role and impact of investment in economy was treated, in the same way, through input-output analysis in Dobrescu E, Gaftea V, Scutaru C, *Using Leontief Matrix to Estimate the Impact of Investments upon the Global Output.*

An economic growth based on European funds is consistent with the policy set in Romania for the euro adoption, which will be easier to achieve in the condition of increasing absorption of European funds and an adequate modeling support, based on the input-output model.

There is a high probability that the Romanian economy faces in the coming decade a new reduction in capital flows, similar to the years 2008 - 2011, in the context of a new global economic crisis. Thus, it is imperative that Romania be ready for the future crisis and focus on absorbing European funds and attracting foreign direct investments in order to boost the total factor productivity.

The efficient use of niches in the European, Asian, Russian and U.S. markets is the main action that may ensure the needed economic stability in the future, by boosting export growth. This requires accurate sectoral modeling capability of the economy. Stability is mentioned, because through the structural analysis of the competitiveness, we have found that the economic development over the last 22 years has shown the ability to be sustainable, except for the period 2000-2008.

Thus, the modeling is useful in the drafting of recommendations for Romanian policy makers with respect to the economic sectors that should receive, with priority, the attention of policy makers and European Funds in the next planning period, 2014 – 2020, considering the competitiveness and added value in various economic sectors, the multiplier effects of investments in these sectors, results identified in the analysis based on I-O modeling.

7. Conclusions

The conclusions of this modeling work highlight, to economic policy makers, both the more attractive and competitive branches or sectors as well as those with problems. The analysis methodology based on I-O tables, which is applicable at any level of aggregation of branches, allows for a more relevant and target-oriented competitive analysis.

There are real threats to the economy, of medium probability, such as the worsening Eurozone crisis and the increasing support of foreign banking groups, a negative reaction of the population and politicians to reform, reduced access to EU funds and the lack of access to international financial markets.

The level of social security and income taxes, or of VAT, the calculation of the collected amounts if these taxes would be increased by one percentage point, are also problems for which the proposed I-O model provides the information and technical support.

In conclusion, the research on the above mentioned topics, as well as this summarizing I-O model, become a significant and pragmatic scientific contribution to the efforts of the scientific community, especially through the great research and the modeling activities of Professor Emilian Dobrescu, to identify ways and means of action to increase the competitiveness and sustainability of the Romanian economy. The paper incorporates the experience accumulated through the utilization of classic I-O models, expressed by the main macroeconomic behavioral relationships and econometric estimations of input-output coefficients.

The presentation of the various approaches allowed an awareness of issues that exist in the economy and provided researchers and macroeconomic policy makers with the elements on which the achievement of several targets is dependent. Moreover, the presentation highlighted the potential impact of these elements on the rest of the economy.

In conclusion, Table 5 presents by using I-O the evolution of the Romanian economy transition to a market economy at three time points that mark the two decades between 1989 and 2009, and the major structural changes in the seven aggregated sectors.

Table 5

Share of sectors in GDP, changes in two decades 1989-1999 and 1999-2009

	1989	1990	. . .	1999	. ..	2008	2009
Agriculture, forestry and fishing	0.142	0.179		0.128		0.074	0.072
Mining, Energy production	0.083	0.072		0.085		0.064	0.071
Industrial sectors, Manufacturing	0.452	0.426	⇩	0.262		0.242	0.243
Constructions	0.054	0.052	⇧	0.05		0.109	0.108
Transports, Post, Telecommunications	0.075	0.062	⇧	0.095		0.106	0.111
Trade and business services, Tourism	0.13	0.136		0.296		0.301	0.289
Public services	0.064	0.073		0.085		0.104	0.106

Source: Analysis made by the author based on the Statistical Yearbook of Romania data.

This contribution, which is the result of an individual pursuit, is materialized in the proposed I-O modeling framework, in the advanced modeling tools, in data covering national macroeconomic statistics over a period of over 22 years of input-output tables and macro indicators. Moreover, the modeling technical support was created by the application of working models and structures for structural analysis of competitiveness, simulations and forecasts.

The improvement and the usage of the modeling capacity for the economic forecast is the way that can help to achieve macroeconomic targets.

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