ORIGINAL PAPER

DOI: 10.26794/2220-6469-2021-15-1-60-74
UDC 330.53(045)
JEL B41

Potentials and Limitations of "Input-Output" Analysis (To the 60th Anniversary of Statistical Work in the Field of Intersectoral Research in the CIS Countries)

L.A. Strizhkova[a], G.O. Kuranov[b]
[a] Centre for Macroeconomic Forecasting and Structural Research of Russian Foreign Trade Academy, Moscow, Russia;
[b] Ministry of Economic Development of the Russian Federation, Moscow, Russia
[a] https://orcid.org/0000-0002-0608-1652; [b] https://orcid.org/0000-0001-7209-7823

ABSTRACT
The article reveals the possibilities of using the Russian system of input-output tables and intersectoral models for analytical and forecasting purposes and substantiate managerial decisions in the field of economic policy. It is shown how the input-output method's capabilities were implemented at three stages of the development of intersectoral research in Russia, taking into account the specifics of the problems being solved and the development of the statistical base. The primary attention authors paid to the current stage of developing the method and its use directions. A characteristic is given of the constraints objectively inherent in this method and the input-output tables' information system (IOT). The authors' position regarding their significance is expressed. A new direction in using data from the IOT system is considered — the analysis of the final product's cost as accumulated value-added, which implies a full use of the analytical potential of modern input-output tables. Proposals are given for improving the intersectoral toolkit based on taking into account the links between production, the need for investment and the state of the production and technical base.
Keywords: input-output table system; IOT; input-output method; cross-sectoral research; cross-sectoral tools; modeling; IOT constraints; IOT-based analysis; final products; added value

For citation: **Strizhkova L.A., Kuranov G.O. Potentials and limitations of "input-output" analysis (To the 60th Anniversary of statistical work in the field of intersectoral research in the CIS countries).** ***Mir novoi ekonomiki = The World of New Economy*****. 2021;15(1):60-74. DOI: 10.26794/2220-6469-2021-15-1-60-74**

THREE STAGES IN THE DEVELOPMENT OF INTERSECTORAL RESEARCH IN RUSSIA

In 2021, two related anniversaries for national statistics were celebrated: 60 years since the **first inter–sectoral balance** of the economy of the USSR was released in monetary and physical terms (the latter was a unique development in international practice) and 95 years since the first material product system (MPS) of the USSR. The work of the Central Statistical Office of the USSR on MPS was the first worldwide statistical implementation of the balance sheet method to reflect the production proportions of the economy in the form of a balance sheet system.

The approach applied to the compilation of the USSR MPS gave impetus to the world–renowned research of V.V. Leontief in the field of the theory of the tables "input–output" (IOT) in the concept of the System of National Accounts (SNA) and the practice of cross–industry modelling, which have become the basis for statisticians and analysts in many countries of the world, including Russia [1]. Presentation of the complex history of balance sheet development in the USSR and Russia and related discussions is devoted to a number of interesting materials prepared by Russian statisticians and scientists [2–6].

Then, in the 50–60s. 20th century, the basis of further productive work by Soviet economists in the field of intersectoral research was laid down. Important milestones in the development of the balance sheet method, intersectoral research and intersectoral Soviet–era modelling are related to names P.I. Popov, L.I. Litoshenko, V.S. Nemchinov, A.I. Efimov, M.R. Adelman, L.Y. Berry, F.N. Klotsvog, E.B. Ershov, E.F. Baranov, V.V. Kossov, L.E. Mintz, S.S. Shatalin, A.G. Granberg, Y.V. Yaremenko, and A.G. Aganbegyan, Y.M. Urinson, V.D. Belkin, R.A. Belousov, A.A. Konyus and some economists.

It should be noted that the translation and publication in the Soviet Union in 1958 of the fundamental work of V. Leontief and his collaborators on the study of the U.S. economy helped to popularize the ideas of intersectoral balance [7], and later, in the early 1960s. has been translated into Russian on the problems of intersectoral research by Hollis Chenery and Paul Clark, Isamu Jamada and Richard Stone.

In the USSR, cost, monetary and physical and interregional inter–industry models were created and solutions for their dynamic and optimization statements have been developed. The focus was on the optimal allocation of resources, pricing, improving economic efficiency through the implementation of STP (scientific and technological progress) achievements.[1]

Experts have tried to reflect the impact of scientific and technological progress in the direct input factors of the cross–industry balance sheets. Numerous sectoral institutions were involved in their development in the planned perspective. These studies were complemented by the Y.V. Yaremenko group's work on structural models, on accounting for the qualitative heterogeneity of resources and on priorities in their allocation.

The innovative ideas of Y.V. Yaremenko, while remaining highly relevant, define important directions of work in the field of analysis and cross–industry modelling today [8]. Many of the results of other scientists (related to the dynamization of the IOB–model, taking into account price and income, labour and fixed capital, resource substitution, etc.) have become a source of ideas for a number of modern applications of economic modelling.

Unfortunately, in the 1990s the accumulated knowledge potential in the field

[1] Economic and Mathematical Research / World History of Economic Thought. Domestic Economic Science. V. 6. B. 1, section YI, ch. 27. M.: Thought; 1997. URL: https://www.booksite.ru/fulltext/oie/mys/ly/index.htm.

of intersectoral research wasn't adequately utilized in the management system, which was noted at the international scientific–practical conference "Input–Output balance — history and perspectives", organized in honor of the 50th anniversary of the development of the first USSR input–output balance (IOB).[2] Despite the obvious need and the possibility [9] of using cross–sectoral tools during the transition period to improve the quality of public administration, research in this area has slowed markedly.

This was due in large part to objective difficulties in reforming the statistical system and drastically reducing the budget for statistical work. Both the underestimation of statistical data requirements in the context of deviation from the planning and administration system and the perception of the high–cost statistical development of IOB tables and cross–industry models as being mainly suitable for administrative planning.

The first set of Russian "input–output" tables in the 1995 SNA concept was published by Goskomstat only in 2000 on the basis of the results of the large–scale business survey, i.e., thirteen years after the last fundamental input–output balance data production (1987). At the same time, the need for economic projections of a country in the 1990s (for annual and then three–year budget planning) also determined the need for instruments to balance and harmonize macroeconomic and sectoral projections.

During these years, gaps in statistical estimates of the input–output balance were regularly filled by the IOT pilot estimates performed at the Institute of Macroeconomic Research (Russian Foreign Trade Academy).[3] Cross–sectoral research work was also supported in a number of academic institutions (Institute of Economic Forecasting, Russian Academy of Sciences and etc.). By providing a basis for model calculations, they have played a positive role in preserving the culture of intersectoral research in research teams, and have contributed to the development of approaches to modeling the country's economy in market conditions.

Since the beginning of the 2000s in Russia there has been a renewed interest in the subject of intersectoral modelling, which has increased markedly in recent years. Both this is related to the significant improvement in national reporting on the input–output table system and the recovery processes in the Russian economy, and with increased demand for model tools in government organizations in economic decision–making and transition to strategic planning. The activity of Russian scientists was stimulated by trends in world economic science and the emergence of new foreign publications [10–14].

The globalization of world linkages and cross–country integration have given impetus to new directions in the use of IOT tools, as well as the need to study its mixed effects on national economies and the world community as a whole, and new theoretical concepts aimed at explaining observed patterns (including the concept of trade in value added). Based on the world's IOT international databases (in some of them — WIOD, OECD ICIO, EORA, GTAP–MRIO — included Russia) are being used to develop cross–country cross–sectoral models and provide in–depth analysis

[2] International Science and Practice Conference Intersectoral Balance — History and Perspectives 15 April 2010. M.: GA IMR; 2011. 228 p.

[3] One of the areas of specialization of GA IMR (formerly SIER under the State Plan of the USSR, and now, after joining the RFTA Ministry of Economic Development of the Russian Federation,— IMR RFTA) — development of operational (expert) evaluations of the IOT system on the basis of the reports of Rosstat, FCS, Cebtral Bank of Russia, etc. sources. Estimates have been produced annually since 1993 to provide timely information on the cross-sectoral IMR model and the model apparatus of the Ministry of Economic Development of the Russian Federation for the last year preceding the forecast period.

of the world economy and to assess global development scenarios.

Modern statistical work on the IOT system is conceptually aligned with the SNA– 2008 methodological recommendations, other UN and Eurostat publications.[4] The Russian classifiers of types of economic activity and products are harmonized with international ones, which, given the complexity of the tasks to be performed in the course of constructing the IOT, is considered to be a great merit of statisticians. However, there is a lack of detailed methodological explanations by Rosstat on the construction of the IOT system with references to statistical observation forms among professional users of IOT, supporting assumptions, interpretations of a number of SNA indicators in the annex to Russian features. The latest detailed material on this subject published by Rosstat more than 20 years ago.[5]

With regard to the continuity of knowledge, it is important to note that 2019 was a milestone in the educational process — production, after a long break, of a national specialized textbook devoted entirely to the topic of "input–output",[6] where the fundamentals of the IOT system and its potential application in macroeconomic modelling are clearly described.

STATISTICAL RELEVANCE AND ANALYTICAL CAPACITY OF IOT

The "input–output" table system (IOT system) is an important part of a country's SNA, revealing the positions of its consolidated accounts (goods and services, production and generation of income) at the level of types of products and groups of industries, and also the impact of transport margins, trade margins, net taxes on products, on the increase in the price of products in basic prices to the value in buyers' prices for different groups of consumers.

Regular development of IOT,[7] compilation of food balance sheets that are consistent with the records of enterprises, departments and population surveys, significantly increases the reliability of estimates of macroeconomic aggregates (GDP and its components). With the extensive use of the sample survey method and the need for estimates of the non–observed economy, it is difficult to overestimate the importance of IOT for statistical purposes as a balancing tool.

The composition of the IOT tables published by Rosstat contains virtually all the relevant tables for analysts to describe the structure of production and end–use of goods. The basic tables are quite representative of the composition of the branches and types of products allocated. For example, in the published core tables for 2016, the OKVED 1.1./OKPD 1.1 classifiers identify 206 product types and 98 industries, the dimension of the symmetrical IOT (commodity by commodity tables) was 95×95.

The dimension of the summary tables in the intermediate years between the output of the basic tables is significantly lower. With the transition to the new OKVED 2/OKPD 2 classifiers, the dimension of the summary tables for 2016–2017 improved slightly: from (59×59) to (61×61), and unfortunately,

[4] The System of National Accounts 2008. In 2 vol. Transl. European Commission, IMF, OECD, UN, World Bank. New York; 2012. 764 p.; Eurostat Manual of Supply Use and Input-Output Tables). Eurostat; 2008.; Handbook on Supply, Use and Input-Output Tables with Extensions and Applications. United Nations, New York; 2018.

[5] Methodological provisions on statistics. Issue. 2. M.: Goskomstat of Russia; 1998.

[6] Sayapova A. R., Shirov A. A. Fundamentals of input-output method. Book. M.: Ltd Maks Press; 2019. 336 p.

[7] The system of "input-output" tables with data for years of their estimation is presented on the website of Rosstat (https://rosstat.gov.ru/). Includes 8 core tables (of goods and services; use of goods and services at buyers' and basic prices; use of domestic products, imports, transport and trade margins and net taxes on products) and a symmetrical IOT. Symmetric tables are published for base years. Base years — when large-scale statistical surveys of organizations are carried out. "Input-output" tables for base years are called "base" tables.

however, the representativity of the data in the section "Extraction of mineral resources" was significantly reduced, which became reflected in one row and one column (previously the dimension was 5×5). This decline in data for one of the most important sectors of the economy is quite surprising. But on the whole IOT system — is a rich source of information for structural and comparative (cross–country, temporary) analysis of the Russian economy, identification of "bottlenecks".

There are three ways in which IOT data can be used in a given year's economic situation:

- direct analysis that relies directly on the data in the tables, for example, the estimation of the element structure of costs, the share of imports in costs, the distribution of domestic and imported inputs by direction of use, the tax component's share in the value of used products, the share of knowledge–intensive and high–tech industries in exports, etc.;
- more in–depth analysis based on transformed data, using matrices with full–cost ratios, which makes it possible to assess the relationship between final demand in a given direction and the formation of output, imports and value added in different domestic industries, dissect the value structure of the final product, etc.;
- extended in–depth analysis with complementary data, in particular on labour, capital stock, investment, energy balances and environmental performance. Within this line, the full costs of the relevant types of inputs and the characteristics of the full "ecological burden on the economy" associated with the production of different types of final domestic production can be estimated.

The results of the analysis using IOTs in the identified areas, especially in the temporal dimension, are not only of scientific interest. They are of practical importance to government: they are used to provide predictive and scenario analysis, to develop hypotheses, to select solutions. IOT information (both reporting and forward–looking) can be useful for business entities working in a particular area of the economy. Of particular interest in that context can represent information in rows "Table of use of goods", description of demand for domestic and imported products in selected segments of the domestic market.

Many publications contain some of the results of the IOT analysis, some of them using an innovative calculation methodology.

In our view, it would be useful to synthesize the accumulated experience into a single material, where the methodological basis of the analysis of the economy on the basis of the IOT is organically supplemented by a description of the methods of implementation of non–trivial aspects of the analysis taking into account the peculiarities of Russian statistics, and with a clear explanation of the practical significance of the result for managers.

INFORMATION AND METHODOLOGICAL LIMITATIONS OF THE IOT SYSTEM

In the economic environment, with a generally weighted approach to assessing IOT limitations, there have always been, and there are, strong critics and even opponents of the "input–output" method [15, 16]. In some cases, a strong criticism of the IOT method is related to the absolute limitations of the IOT information system. In some instances, there is opposition to the theory and methodology of the SNA as a whole, for example, by moving away from business practices to abstract categories or for other reasons. Often, criticisms are simply rewritten from other sources, sometimes seemingly without understanding their methodological validity.

By the limitations of the IOT information system we understand its peculiarities that limit the possibilities of economic analysis and modelling on the basis of it, as well as some imputations in the estimates that may be associated with some imputation on the IOT basis that are objectively conditioned by the IOT methodology.

In the first group of restrictions may include:

1. Lack of a sufficiently representative time series of IOT system tables compiled in a single methodology. Over the last 25 years, analysts have methodologically comparable data on the IOT by brief system for 1995–2003; then, after an eight–year break, for 2011–2016 (but already in updated classifiers and refinements in methodology); then a radical change of the classifiers takes place again, and analysts receive IOT data for 2016 and 2017 in modern classifiers and methodology (SNA-2008, OKVED 2, OKPD 2). With the understanding that Russian IOTs should fit into the international system of methodological requirements, the associated limitations of analysis and forecasting on the basis of the "input–output" method cannot be denied.

2. Lack of statistical practice in compiling the IOT system in constant prices. It should be noted that this does not contradict the requirements of international organizations to national IOT. Nonetheless, it should be noted that the SNA-2008 (chapter 14, 15) notes the importance of compiling the "Table of use of goods and services" in constant prices and gives recommendations on this issue.

Such developments are important for improving the reliability of IOT statistics and their consistency with price statistics. For IOT users, the absence of such developments limits the ability to identify the time–to–time relationship between utilization indicators through volume indices and cost deflators, factor analysis, including direct cost factors.

Second group of restrictions — conditional in IOT estimates

1. Certain convenience of indicators I and III quadrants of the Symmetric table "input–output" (SIOT), which in Russian statistics is formed in the format "commodity by commodity". Its main purpose — is to reflect the non–statistically observed structure of output costs by product type (the so–called "net" evaluation principle). This makes it possible to estimate a matrix of direct cost factors SIOT, the use of which in the calculation of full cost factors gives them economic value.

Moving from "Table of use of goods and services" to Quadrant I and III estimates, based on the reporting of institutional units in the format of "product to industry", to the I and III quadrants of SIOT, mathematical methods based on certain assumptions are used,[8] which defines some arbitrariness of cost estimates and coefficients of direct and full costs in the SIOT. Reason for this convenience is objective: the availability of secondary products in industry outputs and the need to aggregate data in the production of IOTs. The level of deviation of the estimates in SIOT from the unknown real values depends on the aggregation of the data: the higher the detail, the smaller the deviation.

2. Other imputations related to aggregation. To a certain extent there will always be some conditionality in the compilation of deflators for resource flows by the cells of "Table of use". This is due to differences in internal product flow patterns of the species *i*, used by different consumer groups. Almost any species aggregation (*i*) combines many specific products (total — several tens of thousands). Because it is not feasible to separate them by use and uncertainties of the measure of

[8] Known mathematical solutions for the SIOT format "commodity by commodity": the method of industry technologies, the method of product technologies, their hybrid versions. The industry technology approach assumes that a single technology is applied for all products processed in the industry j, but in the method of product technology — that a single technology is used in different industries of the same type of product i. Each of the methods has its pros and cons, as described in the UN guidance materials, and none, due to the unavoidable aggregation of products into species groups, is able to estimate the cost structure of net releases with 100% accuracy.

structural heterogeneity of thread flows is considered acceptable to the indicators of the row "Tables of use of domestic products in basic prices" apply a single "line" deflator for all directions of domestic use (in addition, of course, to exports). The same approach is applied to the construction of deflators by cells "Table of use of imported goods".

The accuracy of indicator deflators in row cells depends on the aggregation of data (it increases with more detail). This has an impact on the estimation of volume indices of the use–oriented grouping of the product *i* and macroeconomic aggregates, including expenditures on intermediate consumption and gross value added (GVA) of sectors of the economy.

3. Convenience associated with the acceptance of the SIOT–based matrix of direct cost factors as the "technological matrix" of the economy. Currently, as noted in the SNA-2008, the definition of this matrix as "technological" is becoming increasingly conditional. In particular, this relates to the development of goods processing services (domestic, imported) without transfer of ownership and the adoption of the IOT treatment of these transactions. The value of the processed goods is not included in the value of the processor's intermediate consumption, but only the value of the processing services is included in the output. This estimation approach *"changes the nature of input–output factors. They no longer describe the technological structure of the production process but the economic process"* (SNA-2008, chapter 14). This limits the study of technological changes in production to a matrix of direct cost factors.

Thus, the IOT data system (as with any macro–level statistical information) has a number of limitations for quite objective reasons. Among the most disturbing are the gaps in information, which are being addressed in a number of scientific communities [17–19]. IOT limitations related to methodological reasons do not seem to be critical (taking into account the principle of acceptable tolerance), but they need to be "kept in mind".

It should be noted that we do not include in the IOT information limitation list the so–called "problem the four quadrant" — the implicit shift from primary income from productive activities to final consumption and savings expenditures, mediated by the redistribution of financial resources between institutional sectors. This shift is reflected in other SNA accounts with which IOT has aligned for the reporting years.

At the same time, while we fully agree on the importance of taking this connection into account in forecasting, we stress that it is a general problem of modeling the economy using any method, including the "input–output" method.

Cross–sectoral model based on the IOT of the reporting year — is a statistical model based on the "input–output" method (IO method) and linked to the structure of the reporting year. The mechanism of operation of the model is based on the laws of linear algebra (matrix operations). The model needs a large amount of initial (exogenous) information to be applied in scenario predictions. But this is not a reason for disappointment with the IO method, given its unique balancing properties and high analytical potential. It merely took that successful macroeconomic forecasting requires combining balance sheet methods, including the IO method, with other methods and aspects of forecasting.

This is realized in a modern cross–industry toolkit by means of extended (multi–block, factor–based) cross–industry model productions, creating model systems that integrate the development models of economic segments and the cross–sectoral model.

USE OF CROSS–INDUSTRY TOOLS IN SCENARIO CALCULATIONS

The use of cross–sectoral tools in public administration makes it possible to meet the challenges of balancing forecasting in the light of production constraints and assessing the reaction of the economic system to changes in business conditions.

In terms of the scope of the study and its structure, three major classes of cross–industry models can be identified for scenario analysis and prediction: a) national economy; b) Russian regions and economies in regional level; c) Union State, EAEU — by EAEU member States.

The development of model tools for the solution of the last two groups of tasks is to a large extent constrained by the difficulty of developing regional IOTs for Russia and inter–country IOTs in the EAEU area. Nevertheless, a number of important results have been achieved in the scientific community. First of all, the work of specialists of Institute of Economics and Industrial Engineering, Siberian Branch of the Russian Academy of Sciences and Institute of Economic Forecasting, Russian Academy of Sciences on Russian interregional modelling [20–24].

Support for research in this area and its use in the practice of State administration will help to solve current problems in the area of territorial development in Russia.

Also noteworthy is the pioneering work of the Institute of Macroeconomic Research (Russian Foreign Trade Academy)[9] on the compilation of intercountry IOT (SIOT) for EAEU countries. This allows an assessment of the macroeconomic effects in the EAEU area related to the economic policies of EAEU governments, business structures and external influences. Taking into account such effects is important for the formulation of agreed decisions by countries in order to realize the Union's integration potential more fully and thus improve the competitiveness of economies and the living standards of the population.

The most widely used model systems in Russian public administration are currently focused on the first group of tasks. A similar model system, in which the cross–sectoral model is allocated to the corresponding unit of calculation, where information from other units of the system is received, is used in the Ministry of Economic Development of the Russian Federation. This model is used mainly for balancing tasks and is markedly less used for other analytical purposes.

As a balancing tool, the cross–sectoral model is required in predictive calculations. According to the forecasting technology at the federal level, the balancing properties of the model are used both at the stage of development of the scenario conditions and in the process of mutual agreement on sectoral designs that are formed in the sectoral departments according to the scenario conditions. As a tool for analysis, different versions of the cross–sectoral model have been used to assess the macroeconomic effects of individual financing decisions from fiscal sources, import substitution programmes, tax and price policies, etc.

For example, the cross–industry model helped in the mid-2000s to assess the inflationary impact of planned tariff changes for natural monopolies and contributed to the decision to set lower–than–planned tariff ceilings for these services. It, along with other tools, was used in the evaluation of the effects of the realization of the infrastructure project "Eastern Polygon". Assessment of macroeconomic effects — is one of the most

[9] The work on the topic "Development of the methodology for the construction of the cross-country table "input-output" of the Eurasian Economic Union, experimental calculation and evaluation of the integration potential of the Union on the basis of it", was carried out within the framework of the Treaty of IMR Ministry of Economic Development of the Russian Federation with the International Organization Eurasian Economic Commission of 27 July 2018 No. N-07/225.

interesting and complex areas in the use of high–speed cross–sectoral tools [25–27].

Most of the production versions of the cross–industry model are based on the classic "Leontief" scheme. The practical use of this scheme requires a weighted approach and opens up new possibilities for analysis with a fairly complete set of tables in the IOT system.

Availability of Tables of use of domestic products enables the full cost matrix to be evaluated on the basis of this matrix (not based on the table of use of goods in fixed prices). This is theoretically correct in estimating the need for domestic production, as import costs should not be factored into the multiplication of direct cost factors to arrive at full (see infinitely decreasing geometric progression limit formula[10]).

Otherwise, full input ratios and output estimates will be overestimated/underestimated with changes (increases/decreases) in final domestic output. The availability of import use tables allows for a more accurate estimation of the need for intermediate imports[11] based on the estimation of import direct cost factors.

According to the concept of cross–industry and inter–temporal transfer of values in the annual production process, the valuation of final domestic production in basic prices can be considered as the result of the accumulation of value added in the economy, i.e. a summary of GVA, intermediate imports (foreign value added) and net product taxes (NNP — net national product) included in intermediate costs.

Consequently, it is possible to analyse the internal structure of the values of domestic final output as carriers of value added.[12] The essence of the analysis is the decomposition of the value of the final product of the species *i* by source of education and the assessment of the role of each source.

The implementation of such structural analysis is ensured by the up–to–date composition of the IOT tables and opened up the possibility:

• assessment of the impact of point measures on final demand and on the formation of GVA as an impulse for different groups of producers;

• obtain additional information on the internal market of final products of *i* from imports, as the full measure of participation of all imports in the value of this final domestic product is *clearly identified*;

• assessing the evolution of the need for intermediate imports with shifts in the composition of final demand and anticipating possible negative effects in the light of development objectives;

• assessment of *the effects of tax policies and other pricing factors,* which are reflected in the structure of the value of final domestic production in basic prices in the change of NNP share parameters, as well as tax and other indicators of the internal composition

[10] $\Delta X = \Delta Y + A\Delta Y + A(A\Delta Y) + A(A(A\Delta Y) + \ldots A(A^n\Delta Y) + \ldots = \frac{\Delta Y}{(E-A)} = (E-A)^{-1}\Delta Y$, where ΔX — change in output vector due to change in final demand for domestic products ΔY; A — a matrix of direct cost factors, $(E-A)^{-1}$ — full cost factor matrix.

[11] Need for intermediate import of $IMpp^t$ estimated as a function of the vector of final domestic production KI^t_{OT} and the coefficients of the full import cost matrix per unit of final domestic production B^t_{IM} or, the same as the function of the calculation vector of Xt output and the coefficients of the matrix of direct import inputs per unit of output A^t_{IM} : $IMpp^t = A^t_{IM} \cdot X^t = B^t_{IM} \cdot KI^t_{OT}$, where $B^t_{IM} = A^t_{IM} \cdot B^t_{OT} = A^t_{IM} \cdot (E - A^t_{OT})^{-1}$.

[12] A typical calculation formula can be used to estimate (decomposition into components) the composition of the value of the final domestic output of type j, used by direction *k* (KI_{OTjk}):

$$IC_{domjk} = \sum_i d_{GVAi} \cdot b_{domij} \cdot IC_{domjk} + \sum_i d_{NPPi} \cdot b_{domij} \cdot IC_{domjk} + \sum_i b_{IMij} \cdot IC_{domjk}$$

where: d_{GVAii} and d_{NPPii} — elements of diagonal matrices with shares of GVA and NNP respectively in output; b_{OTij} and b_{IMij} — The full cost factors, respectively, of the domestic and imported products of type *i*, per unit of final domestic production of type *j*.

The components of the first two sums in the formula show the value added of domestic production *i* that was directly and indirectly involved in the creation of domestic output of type *j* for final use in the k direction included in the value of that output. The components of the third sum show the contribution of imported value added (imports of type *i*) to the value of these products.

Table

The role of end-user sectors in the formation of GDP and the ratio of the elemental composition of the value of products in end-use to GDP in 2018 (% of GDP, experimental estimates)

GDP 2018 = 104 630 billion rub.	Economy	Sector 1 "FC"		Sector 2 "GCF"		Sector 3 "Export"				
		subsec-tor G	subsec-tor S	subsec-tor G	subsec-tor D	set subsector G	Of which subsector			subsec-tor S
							Gen	Gee	Got	
1. GDP (1.1+1.2)	**100.0**	**15.4**	**41.6**	**3.6**	**11.8**	**22.2**	**14.4**	**1.2**	**6.6**	**5.3**
1.1. GVA (2.3.1+2.3.2)	*89.7*	*10.1*	*40.3*	*3.3*	*11.6*	*19.2*	*11.5*	*1.2*	*6.5*	*5.3*
1.2. NNP (2.2+2.3.4)	*10.3*	*5.4*	*1.3*	*0.4*	*0.2*	*3.0*	*2.9*	*0.0*	*0.1*	*0.0*
2. EUP to *z* buyers*	**120.6**	**22.3**	**46.5**	**8.3**	**13.6**	**24.1**	**14.9**	**1.6**	**7.6**	**5.7**
2.1 Import to IC	11.5	4.9	2.4	3.9	0.4	0.0	0.0	0.0	0.0	0.0
2.2. NNP in EU	8.8	5.2	0.4	0.3	0.0	2.9	2.9	0.0	0.0	0.0
2.3. EUPdom in basic prices	**100.3**	**12.3**	**43.8**	**4.2**	**13.2**	**21.2**	**12.0**	**1.6**	**7.6**	**5.7**
2.3.1. GVA direct producers	52.8	3.6	28.2	1.3	6.4	10.4	7.1	0.5	2.8	3.0
2.3.2. GVA co–owners, including:	36.9	6.5	12.1	2.0	5.2	8.8	4.4	0.7	3.7	2.2
in the production of goods	15.5	3.8	3.0	1.1	2.0	5.1	2.7	0.4	2.0	0.6
in the production of services	21.4	2.8	9.1	1.0	3.1	3.8	1.8	0.3	1.7	1.7
2.3.3. Import to IC (sector full cost)	9.1	2.0	2.5	0.8	1.5	1.9	0.4	0.4	1.1	0.4
2.3.4. NNP in IC	1.5	0.2	0.9	0.1	0.2	0.1	0.0	0.0	0.1	0.0
Import of all (2.1+2.3.2)	20.6	6.8	4.9	4.7	1.9	1.9	0.4	0.4	1.1	0.4
Full import intensity of domestic products in EU (2.3.3./2.3.*100)	9.1	16.1	5.8	19.5	11.1	**8.8**	3.6	23.7	13.9	**7.3**

Product's end–user (end–use) sector designations: FC — final consumption; GCF — gross capital formation; G — "goods" in the sector (OKPD 2 codes: 01–39); S — "services" in the sector (OKPD 2 codes: 41–98); Geng — energy exports (coal, oil, gas, oil products); Gee — engineering export; Got — other export goods.
Indicator symbols: GVA — gross value added; NNP — net taxes on products of everything; EUP — the volume of products in end–use; EUPdom — the volume of domestic end–use products; Import to EU — imports received for end–use; Import to IC — imports received for intermediate consumption; NNP in EU–NNP added in end–use; NNP in IC — NNP included in intermediate consumption.
* transport and trade margins in the cost of goods at buyers' prices by sector CI are accounted for in the service subsector.

Source: calculation by the authors according to the experimental input-output tables developed at IMEI VAVT for 2018 based on the current statistics of Rosstat.

of GVA, which can also be explicitly included in such an analysis. Note that the content of tax policy analysis can be enhanced by the decomposition of the NNP matrix.[13] In general, the implementation of the stated approach to the analysis of the value of final domestic production not only confirms that any tax on the producer is ultimately paid by the consumer, but also that excessive tax increases can harm producers (of the components of GVA as the *i* final product);

- estimates of the value added of imports and the domestic economy in terms of exports and exports of each product, which meets the analytical challenges of international trade in value added.

Some of the results of the experimental calculation for 2018 using the described method of decomposition of the value of products, received to end-use (EU), are presented in *the table* where data are shown as% of GDP. The sub-sectors "goods" and "services" of the three UU sectors were considered — final consumption (FC), gross capital formation (GCF) and exports. The data explicitly reflect the structure of the value of the final product, the value of the domestic product for each area of demand; "participation" of demand for selected subsectors in the GDP of the economy; capacity of each demand line to initiate GVA in related production, full need for intermediate imports and tax revenues.

For example, the highest relative capacity to initiate GVA in related activities was in demand for final consumption goods, the lowest — demand for services for final consumption and energy exports.

The consolidated estimates of the full need for intermediate imports for designated UU sectors had a significant impact, in addition to the volumes and supply structure of final domestic production, are specific values of full import intensity coefficients. According to 2018 estimates, at the highest level these values are kept for machine building (0.2–0.4), rubber and plastic (0.32), textile and footwear (0.27), pharmaceutical (0.24) products; the lowest (0.03) — for oil, gas, education and real estate.

Imports accounted for 17% of total economic expenditure on final products. Imports accounted for 31%, 56% and 23%, respectively, of expenditure on consumer goods, goods for gross savings and machine–building exports.

AREAS FOR IMPROVEMENT OF CROSS-SECTORAL TOOLS

Model systems are constantly evolving and improving. For example, one of the activities of the Institute of Macroeconomic Research (Russian Foreign Trade Academy) — strengthening the dynamics of the cross–industry model through the development of the investment and equity cluster and to make explicit the linkages between sectoral demand for investment, the state of the production and technology base of sectoral industries, financial conditions and developing demand for sectoral products. In assessing the prospects of the economy, it is important to link sectoral investment and production projections and to assess changes in the volume, structure and quality of the sectoral production base.

The complexity of the development of the investment and stock bloc is determined by the known volatility of the annual rate of return on capital and fixed investment, the absence of time series that are methodologically compatible with investment and the estimation of the principal of the economy.

To date, proposals have been developed to explain the dynamics of fixed investment, based on the method of investment decomposition. In particular, a formula has

[13] The NNP table is compiled as the sum of the tables of each tax category (excise, VAT, customs duty) and the table of subsidies on products. But this data is not published by Rosstat.

been proposed (1), which takes into account the three factors of investment demand in industry *i* per year *t* (Inv_i^t):

a) "lag" of the capacity–building process as measured by the link (α_i) to investments of the previous year (Inv_i^{t-1});

б) the necessity of maintaining a production base, as measured by the link (β_i) with the industry's stock of fixed capital (Sfc_i^{t-1});

в) Investments related to the expansion of demand and other factors (including changes in the level of utilization of available capacity, etc.) in the context of the growing demand for sectoral products, as measured by the linkage parameter (φ_i^t) ith growth in output of industrial production ($\Delta Prod_i^t$).

The first two relationship parameters can be interpreted as the share characteristics of the respective regressions and the last — as the incremental investment intensity of output in year *t* (excluding the investments associated with the first two factors).

The overall dependency of investments on determinants is expressed by the equation: (1)

$$Inv_i^t = \alpha_i \times Inv_i^{t-1} + \beta_i \times Sfc_i^{t-1} + \varphi_i^t \times \Delta Prod_i^t .$$

The evaluation of function parameters (by OKVED 2) was carried out for the period 2015–2019. In each year the indicators were calculated at the prices of the previous year in order to eliminate the effect of price fluctuations.

The parameters α_i and β_i were determined simultaneously with the average incremental investment intensity φ_i n this period, based on minimizing the sum of squares of residues in equation (1) with residues. For example, for the economy as a whole, α was determined at the level of 0.33; β — 0,056; φ — 3,6. The resulting parameter values α_i, β_i and φ_i are the expected values of these variables in the range 2015–2019 calculated in comparable prices. After evaluating these parameters, the current φ_i^t values can be refined according to formula (1) for zero residues.

It should be noted that such a division is relatively conditional, but that it addresses in some way one of the problems of dynamic cross–industry modelling — the issue of investment sustainability in future investment demand modelling.

CONCLUSION

The development and application of cross–sectoral models in economic analysis and forecasting, initiated 60 years ago, has gone through several significant stages, with varying degrees of demand for IOB models, frequency and intensity of statistical development, tasks to be undertaken in planning, forecasting and managing economic processes, level of development of the models themselves and their specification.

At present, the main range of tasks to be solved with the use of intersectoral tools is not only restored, but also expanded. These include balancing scenario conditions and medium–term projections, assessing the impact of tariffs and tax conditions on the economy, and taking into account the full cost of imports in the creation of final products, Assessing the macroeconomic effects of financing major investment projects and economic sectors, etc. The IOT toolkit has practical application in government and can be a useful source of information for business (in some cases it is already used in this capacity).

The modern IOT system of Rosstat contains almost all the necessary tables for a deep analysis of the economy. However, there are a number of information restrictions for the study of regularities using Russian IOTs. In addition, the IOT methodology determines some unavoidable assumptions in the estimates, which does not prevent the productive use of IOT for modelling and predictive analysis.

The development of statistical work and tools based on IOTs opens up new possibilities for analysis and scenario construction. One such area — is the analysis of the value of the final product as a carrier of value added.

The development of cross–sectoral tools is linked to the reflection of the dynamics of the reproduction processes as well as their relationship to the financial environment of the economy, including through the development of an investment pool in the structure of cross–industry models.

According to the authors, there is a need to update and expand statistical publications with methodological materials for the production of the "input–output" reporting tables, as well as to address at the statistical development level some issues related to the limitations of the IOT information system (in particular the development of IOT at constant prices).

In our opinion, it is also advisable to develop a detailed methodology for the analysis of the economy with the application of IOT (possibly as a collective monograph of key IOT users). On this basis, it is possible to move to a new level of cross–sectoral balance in the management environment in the selection and justification of decisions.

REFERENCES

1. Leontiev V.V. Selected works (in 3 vols.). Moscow: Ekonomika; 2006. (In Russ.).
2. Masakova I.D. The Russian practice of compiling input-output tables: Problems and prospects of development. *Problemy prognozirovaniya = Studies on Russian Economic Development*. 2019;(2):14–26. (In Russ.).
3. Ivanov Yu.N., Ryabushkin B.T. The 90th anniversary of the first Balance of national economy: Origin and evolution of macroeconomic statistics in Russia. *Voprosy statistiki*. 2016;(4):71–84. (In Russ.).
4. Kossov V.V. Revival of the intersectoral balance in the USSR. *Ekonomicheskaya nauka sovremennoi Rossii = Economics of Contemporary Russia*. 2014;(2):103–110. (In Russ.).
5. Ryabushkin B.T. The history of the creation and development of the domestic intersectoral balance and its place in statistics and macroanalysis. *Vestnik Universiteta (Gosudarstvennyi universitet upravleniya)*. 2013;(17):187–192. (In Russ.).
6. Sokolin V.L., Simchera V.M. History of the formation and development of balance works in Russia. Moscow: Statistika Rossii; 2006. 86 p. (In Russ.).
7. Leontief W., Chenery H.B., Clark P.G. et al. Studies in the structure of the American economy: Theoretical and empirical explorations in input-output analysis. New York: Oxford University Press; 1953. 561 p. (Russ. ed.: Leontief W., Chenery H.B., Clark P.G. et al. Issledovanie struktury amerikanskoi ekonomiki. Teoreticheskii i empiricheskii. analiz po skheme zatraty-vypusk. Moscow: Gosstatizdat; 1958. 640 p.).
8. Yaremenko Yu.V. Theory and methodology of researching a multilevel economy. Moscow: Nauka; 2000. 400 p. (In Russ.).
9. Strizhkova L.A. The role of macroeconomic research in state management of the economy in transition. Moscow: Institute for Macroeconomic Research; 1997. 251 p. (In Russ.).
10. Oosterhaven J., Stelder D., Inomata S. Estimating international interindustry linkages: Non-survey simulations of the Asian-Pacific economy. *Economic Systems Research*. 2008;20(4):395–414. DOI: 10.1080/09535310802551448
11. Miller R.E., Blair P.D. Input-output analysis: Foundations and extensions. 2nd ed. Cambridge, New York: Cambridge University Press; 2009. 784 p.
12. Nishimura S. Towards analysis of vertical structure of industries: A method and its application to U.S. industries. Munich Personal RePEc Archive. MPRA Paper. 2010;(27464). URL: https://mpra.ub.uni-muenchen.de/27464/1/MPRA_paper_27464.pdf

13. Aroche Reyes F., Marquez Mendoza M.A. The Demand driven and the supply-sided input-output models. Notes for the debate. Munich Personal RePEc Archive. MPRA Paper. 2013;(58488). URL: https://mpra.ub.uni-muenchen.de/58488/2/MPRA_paper_58488.pdf
14. Kratena K., Temursho U. Dynamic econometric input-output modeling: New perspectives. In: Jackson R., Schaeffer P., eds. Regional research frontiers. Vol. 2. Cham: Springer Verlag; 2017:3–21. (Advances in Spatial Science: The Regional Science Series). DOI: 10.1007/978–3–319–50590–9_1
15. Karganov S.A. On the erroneous use of the economic and mathematical model of V. Leontiev and input-output balances in national economic planning. URL: http://www.econ.asu.ru/mob/pdf/2/begin.pdf. (In Russ.).
16. Ainabek K.S. Methods of forming the input-output balance in the aggregated structure of social production. *SAYaSAT-POLICY. Informatsionno-politicheskii zhurnal*. 2003;(7):69–75. (In Russ.).
17. Salnikov V.A., Galimov D.A., Gnidchenko A.A. Using input-output tables for analyzing and forecasting the sectoral structure of Russian economy. *Problemy prognozirovaniya = Studies on Russian Economic Development*. 2018;(6):93–103. (In Russ.).
18. Strizhkova L.A., Kashirskaya S.I., Novikov Yu.A. Methodological aspects of constructing expert assessments of input-output tables and assessing processes in the Russian economy using cross-industry tools. In: 16th April int. sci. conf. on the problems of economic and social development (in 4 books). Book 1. Moscow: NRU HSE; 2016:438–456. (In Russ.).
19. Baranov E.F., Kim I.A., Piontkovski D.I., Staritsyna E.A. Problems of constructing Russian input-output tables into the international class. *Ekonomicheskii zhurnal Vysshei shkoly ekonomiki = The HSE Economic Journal*. 2014;18(1):7–42. (In Russ.).
20. Blam Yu. Sh., Mashkina L.V. Forming-up hierarchical set of models: Developing strategy for industry specific sector. *Mir ekonomiki i upravleniya = World of Economics and Management*. 2018;18(4):126–139. (In Russ.). DOI: 10.25205/2542–0429–2018–18–4–126–139
21. Baranov A.O., Dondokov Z.B., Slepenkova Yu.M. Construction and using regional input-output models for the analysis and forecasting of regions' economy development. *Idei i idealy = Ideas and Ideals*. 2016;2(4):66–85. (In Russ.). DOI: 10.17212/2075–0862–2016–4.2–66–85
22. Suslov V.I., Domozhirov D.A., Ibragimov N.M., Kostin V.S., Melnikova L.V., Tsyplakov A.A. Agent-based multiregional input-output model of the Russian economy. *Ekonomika i matematicheskie metody = Economics and Mathematical Methods*. 2016;52(1):112–131. (In Russ.).
23. Sayapova A.R., Syrtlanov I.V., Shirov A.A. Cross-country analysis of spatiotemporal characteristics of technological coefficients. *Problemy prognozirovaniya = Studies on Russian Economic Development*. 2015;(6):31–44. (In Russ.).
24. Granberg A.G., Suslov V.I., Suspitsyn S.A. Multiregional systems: Economic and mathematical research. Novosibirsk: Siberian Scientific Publ.; 2007. 371 p. (In Russ.).
25. Buzulutskov V.F., Pyataev M.V., Sizov A.N. Interregional input-output optimization model as a tool for evaluating the efficiency of large-scale railway projects. *Region: ekonomika i sotsiologiya = Region: Economics and Sociology*. 2019;(3):240–266. (In Russ.). DOI: 10.15372/REG20190310
26. Ksenofontov M. Yu., Shirov A.A., Polzikov D.A., Yantovskii A.A. Assessing multiplier effects in the Russian economy: Input-output approach. *Problemy prognozirovaniya = Studies on Russian Economic Development*. 2018;(2):3–13. (In Russ.).
27. Strizhkova L.A., Kuranov G.O., Kolerov S.B. General methodological approaches to macroeconomic assessment of investment projects in the field of transport infrastructure and high-tech industries development. *Sbornik nauchnykh trudov IMEI*. 2014;(4):35–60. (In Russ.).

ABOUT THE AUTHORS

Lyubov A. Strizhkova — Doctor of Economics, Head of the Center for Macroeconomic Forecasting and Structural Research, Russian Foreign Trade Academy, Moscow, Russia
l.strizhckowa@yandex.ru

Gennady O. Kuranov — Cand. Sci. (Economics), Leading expert of the Ministry of Economic Development of Russia, Moscow, Russia
kuranov@economy.gov.ru

The article was received on 29.09.2020; revised on 23.10.2020 and accepted for publication on 15.12.2020.
The authors read and approved the final version of the manuscript.