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MACROECONOMIC PROBLEMS
Problems Using the Input-Output Method for Analysis and Forecasting of Economic Development

Using Input–Output Tables for Analyzing and Forecasting the Sectoral Structure of Russian Economy

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Abstract—The paper describes the experience of analyzing and forecasting various aspects of Russian economy based on input–output tables (1st and 2nd quadrants) estimated by the authors from Center for Macroeconomic Analysis and Short-term Forecasting of the Institute of Economic Forecasting of the Russian Academy of Sciences for the period 1995–2016.

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The beginning of the active in-depth work of the Center for Macroeconomic Analysis and Short-term Forecasting (CMASF) that is related to input-output tables dates back to 1999[1]. The basic methodology that was developed and implemented at the first stage (1999–2000) was further improved by expanding the volume of statistical information used and was adapted in 2005–2006 to the change in the classifications of economic activities (the transition from the All-Russian Classifier of Branches of National Economy (OKONKh) to the All-Russian Classifier of Economic Activities (OKVED)).

The first estimates obtained (since the early 2000s) began to be used both for analyzing the specifics of the development of the Russian economy and forecasting. While in the first decade their use for forecasting prevailed, by the end of the 2000s (especially since the early 2010s) the estimated tables began to be actively used to assess the economic impact of change in policy actions, technological shifts, etc.

It should be noted that presenting a sort of digest on our working experience with input-output tables (IOT) is important at least for two reasons. First, some of the results are published for the first time. Second, in the works published earlier, we did not always emphasized the fact that the results had been obtained using the IOT (in part because the IOT for the Russian economy were not available for a wide range of researchers). At present, after the Federal State Statistics Service published detailed tables in 2017, this seems more than relevant (especially considering the fact that the most highly detailed tables were presented only for 2011).

Methods and tools for prolongation and retrospective calculation of the 1st and 2nd quadrants of the IOT. Undoubtedly, the development of the IOT for 1995 on the highly sectoral basis implemented by the Federal State Statistics Service was very significant for national statistics. However, the scientific community has not received the full access to the IOT, and this work has not been continued. The next IOT of a comparable level of detail were published by the Federal State Statistics Service only in 2017 (according to the data of 2011). The existing "gap" in the statistics was partially compensated for by the Federal State Statistics Service by publishing individual IOT[2] for the period 1995–2006. However, the tables published for these years were developed for the aggregated sectors of the economy, which limited their use in analyzing sectoral changes. Meanwhile, the system of interindustry relations in the period 2007–2011 remained a blind spot for the researchers until 2017. In these conditions, the development of estimated IOT on the basis of the detailed IOT for 1995 was very relevant for analysts.

We based our calculations on 1st and 2nd quadrants of the IOT for 1995, which was developed by the

[1] The decision on the expediency of working out the methods and tools for prolongation and retrospective calculation of the 1st and 2nd balance quadrants on the basis of the "input–output" tables published by the Federal State Statistics Service and other data sources for the purpose of performing the current analysis and forecasting of the Russian economy belongs to head of a laboratory of the Institute of Economic Forecasting of the Russian Academy of Sciences A.R. Belousov.

[2] For example, the tables at purchasers' prices have not been published since 1998, and supply and use tables have not been published until 1998.

Federal State Statistics Service in accordance with the OKONKh[3], and for the period 1996–2003 the estimated tables were formed in the prices of 1995. In 2004, we turned to the prices of 2004, and this year was subsequently used as a base until 2016. The estimation of balances for production, distribution and use of products and services for all years implied the following estimates: (1) changes in resources (output and imports) for each of the detailed sectors; (2) changes in the basic elements of the domestic final demand and export; (3) estimate of interindustry flows X_{ij} and intermediate demand; and 4) calculation of the increment in stocks (discrepancies) and balancing.

Methods for calculating the output dynamics of industries. The estimate of gross output growth rates for industries at comparable prices was carried out in two ways.

The first way is to use the data of the Federal State Statistics Service directly: the C-O form for the period 1996–1998, the Russian Statistical Yearbook for 1999–2004. These sources published the indices of the physical volume of output for different sectors and subsectors of industry in accordance with the OKONKh. Meanwhile, these indices could be used either directly (in the case of full compliance with the sectors from IOT) or as the weighted average value of the subsectors included in the IOT. After the transition of Russian statistics to a new OKVED[4] classifier since 2004, we developed the correspondence tables that allow data to be transferred from one classifier into another[5].

The second way is to use the data of the Federal State Statistics Service on the output of the most important types of industrial products in physical terms. For this purpose, we developed the product classifier that determined the correspondence between products and industries. Relying on these data, the index of the physical volume of output for each of the industries was calculated as the weighted average of the indices of the physical volume of output (the weights are the base year prices). The products basket slightly varied for different subperiods of 1996–2016; on average, the estimate was made for 550 items. The changes in the products basket were partially determined by the appearance of new types of products in the 20-year period under consideration, while the production of others was interrupted. In addition, the indicated period brought about the change in the classifiers in domestic statistics: thus, since 2010, data on the production of goods in physical terms have been published by the Federal State Statistics Service in accordance with the OKPD[6] that was introduced instead of the OKP[7] that was used until 2009, which required the development of additional transitional tables.

Thus, two estimations of output growth rates were obtained for each sector and time point. The estimations with minimal discrepancies in the rows of IOT were chosen for the use in final calculations, although in some cases other estimates were used[8].

Methods for calculating the dynamics of final household consumption. To obtain the estimates of the elements of final household consumption in 1996–2016, one needs the data on their growth in physical terms for all sectors where these elements are nonzero. The calculation of the growth rates of the corresponding indicators relied mainly on the data on the indices of the physical volume of retail sales for basic consumer goods. The rate of change in commodity turnover for a sector as a whole was calculated as the weighted average value of growth rates for individual goods related to the sector (the weights are the commodity structure of the retail trade turnover). The number of goods that were used in the calculation for the period under consideration changed insignificantly and was approximately 60 items[9]. In some cases and for certain types of goods, other sources and indirect estimates were involved[10].

Methods for calculating the dynamics of exports and imports. The sectoral growth rates of exports and

[3] The All-Russian Classifier of Branches of National Economy.

[4] All-Russian Classifier of Economic Activities.

[5] The use of such a forced measure somewhat reduced the quality of the data used, but in general it remained acceptable, especially given that the consistency was almost unambiguous for many subsectors.

[6] The All-Russian Classifier of Products by Economic Activities.

[7] The All-Russian Classifier of Products was adopted and put into effect since 1994 by the Decree of the Russian State Standard Service as of December 30, 1993, No. 301.

[8] For example, in our opinion, the data of the Federal State Statistics Service on the production of bakery products for the long time had a constant discrepancy between the dynamics of output and dynamics of turnover due to the systematic underestimation of a significant increase in the share of small bakeries, which was reflected in the understatement of estimates in the calculations.

[9] Periodical publications of the Federal State Statistics Service such as the "Russian Statistical Yearbook" and "Socioeconomic Situation in Russia" were predominantly used as data sources.

[10] So, the final consumption of automobile tires was estimated using the data on fleet dynamics and expert estimates of the average mileage of a set of tires; the calculations on motor gasoline and electric power were made using the data of fuel and energy balances; the rate of change in the final consumption of the printing industry was estimated based on the data on the circulation of newspapers, books, brochures, and magazines. In addition, the data on the sale of individual food products, natural value balances of the Russian State Statistics Service for commodity resources of certain products and estimates of various research organizations were used.

imports were calculated on the basis of the data on the dynamics of foreign trade for the set of individual commodity groups[11] determined by the availability of information. For the period 1995–2004, the data came from the printed Bulletins of the State Customs Committee of the Russian Federation[12], and the set of products was formed of those six-digit or four-digit items of the commodity nomenclature of foreign economic activities (CN FEA) that provide the greatest coverage of foreign trade operations for each sector. For this period, approximately 500 items were used to assess the dynamics of exports, and approximately 600 items were used for imports. Since 2004, the electronic UN Comtrade Database[13] was used as a source, which made it possible to significantly expand the list of exported and imported commodity groups to more than 1200 items (four-digit items of the CN FEA).

The sectoral indices of the physical volume of exports (imports) were calculated as a change in the volume of exports (imports) of all commodity groups of the CN FEA related to the sector in the comparable prices of the base year. The data on physical volumes[14] by weight were used for the commodity groups for which the unit weight value is representative; the values in dollars (with an amendment for dollar inflation) were used for the commodity groups for which, according to our estimates, the unit value is not representative due to significant structural shifts inside the commodity group[15].

Methods for calculating the dynamics of gross fixed capital formation. This indicator was calculated using the data on investments in fixed assets (the data on their dynamics are regularly published by the State Statistics Service). Specially developed highly detailed investment matrices were used for this purpose (until 2004, in accordance with the OKONKh; for a later period, according to the OKVED). The dimension of the matrix is 102 × 28 (types of activity), for which the changes in gross capital formation are estimated. For other sectors the scale of gross capital formation was not significant.

Methods for calculating intermediate consumption. In the general case, it was assumed that the elements of intermediate consumption do not change in the transition to the next year, since the structure of raw material inputs in sectors is fairly stable unless serious technological leaps take place. Nevertheless, its gradual change is a natural process and must be reflected in the calculations.

The correction of the input coefficients (ICs) in the transition to the next year was carried out taking the following aspects into account. First, in case of an unreasonably large discrepancy while the probability of an error in estimating the dynamics of the remaining balance elements is extremely small. Second, the change should not exceed 10% unless otherwise has a justified confirmation. Third, the changes in the ICs should be meaningfully explained, which must be supported by some other indirect estimates[16].

Calculating changes in stocks and balancing. Changes in stocks were calculated as the difference between supply and use:

$$\Delta Z_j^t = X_j^t + I_j^t - E_j^t - Inv_j^t - Ch_j^t - Cg_j^t - \sum_i X_{ij}^t,$$

where X_{ij} is the flow from the industry i to the industry j; X_j is the gross output of the industry j at purchasers' the prices; I_j is the import of products of the industry j; E_j is the export of products of the industry j; Inv_j is the gross fixed capital formation for the industry j; Ch_j is the final household consumption for the industry j; and Cg_j is the final consumption of government and nonprofit organizations for the industry j.

The change in stocks simultaneously reflected both the actual change and the error related to the specifics of calculating the elements included in the formula. The final balancing was carried out by correcting the elements of the balance, or by choosing between methods for their calculation, or by expert evaluation in case of doubtful quality of the data used in the calculation of an element.

Estimated input–output tables for analyzing and forecasting the development of the Russian economy. *The IOT as the core of the system of integrated forecasting.* During the first half of the 2000s CMASF developed the system for forecasting the development of economic sectors. One of the most important elements of it were the estimations of the 1st and 2nd quadrants of the IOT. This system was a system of interconnected balance or balance-econometric equations, which reflects different processes for each economic sector. The most important of them are as follows: (a) the model for calculating the dynamics of the elements of final demand, intermediate demand, and gross output; (b) the model for calculating price indices; (c) the

[11] The customs statistics of foreign trade were used, which were formed by the Federal Customs Service of Russia (until 2004, the State Customs Committee of the Russian Federation).

[12] "Customs Statistics of Foreign Trade of the Russian Federation".

[13] https://comtrade.un.org/

[14] For some goods, additional units of measure were used instead of weight (pieces, meters, liters, etc.).

[15] As a rule, products of this kind relate to machinery.

[16] For individual flows, auxiliary data sources and estimates were used, for example, fuel and energy resource balances or data on changes in the per-unit consumption for individual types of production processes.

model for calculating the number of employees; (d) the model of the formation of financial resources; (e) the model of working capital financing; and (f) the model of production capacity balances and demand for capital investment.

The system for forecasting the development of economic sectors is closely integrated with a more general macroeconomic model of medium-term and long-term forecasting and in fact is used for "explication", i.e., sectoral detalization of the general economic forecasts for different indicators (and, thereby, their verification).

The main exogenous variables include the following: (a) variables that characterize the dynamics of the structural elements of final demand in the economy as a whole: the final consumption of households, government and nonprofit organizations, gross fixed capital formation, accumulation of stocks, exports, and imports; (b) regulated prices and tariffs (for electricity, gas, and transport services), as well as hypotheses about changes in prices or their ratios (for certain types of products and services); (c) real effective ruble exchange rate; (d) change in the quantity of working-age population and real wages; (e) the most important parameters of the competitiveness of sectors, foreign trade, and the state of world markets, including the dynamics of prices for the main commodity groups of Russian exports; (f) normative parameters of the financial health of sectors; and (g) the most important parameters of renewal of fixed capital.

A very important feature of the model is the high level of its sectoral detalization. While in the first versions of the model the calculation covered 65 types of economic sector, it covers 85 types in the most recent version.

One more important feature is the interconnection of a number of key blocks: change in exports and imports, ICs, and labor productivity is determined by the intensity of investment activity in sectors, while the demand for products of a sector and financial resources of sectors is determined by the dynamics of relative prices. The use of the IOT made it possible to calculate the dynamics of output accounting for the whole complex of interindustry relations and all the main modeling factors that affect the sectoral dynamics of the main elements of final demand and indicators of resource intensity.

The growth rates of output in sectors are determined based on the growth rates of demand for products of a sector, making allowance for the following: (a) the pace of price growth for the sector's products accounting for the different degree of adaptation of sectors to growth in costs due to the planned increase in prices and tariffs for products and services of natural monopolies; (b) the level of competitiveness of the sector's products, which is determined by the availability and rate of commissioning of competitive capacities[17]; (c) changes in the real effective rate and level of tariff protection, which are determined by the dynamics of rates of import customs duties (with consideration for Russia's accession to the WTO); (d) the dynamics of intermediate consumption, accounting for the changes in the efficiency of using raw materials (per-unit inputs); the dynamics of the efficiency of using basic energy resources are determined based on the possibilities for increasing their supply.

The following sequence of calculations is implemented (see Fig. 1). The exogenous parameters "enter" the block for calculating prices and inputs (the parameters are the rates of growth in prices for those sectors that produce the inputs) and the block for calculating the product structure of final demand (the parameters are the dynamics of the elements of final demand and exchange rate). The estimates of the price dynamics for all sectors are subsequently transmitted to the following blocks: (1) the block for calculating the product structure of final demand, (2) the block for calculating gross output, and (3) the block for calculating the balance of production capacities. The sectoral growth rates of demand for domestic products are determined with consideration for the different level of elasticity of demand in each sector relative to aggregated demand (for the final consumption of households, the pace of consumer price growth was also taken into account). The estimates of final demand for products of specific sectors are used in the block for calculating gross output, which is estimated as the product of the Leontief inverse matrix and the vector of final demand.

The data on the volume of output, price indices, and the number of employees enter the block for constructing financial balances (or calculating gross profit). These data serve as a basis for estimating the key financial indicators of the sectors. The blocks for calculating the balance of production capacities and financial balances, which complete the entire cycle of calculations, play a special role within the model. These blocks are "responsible" for the estimates of technological and financial constraints on economic growth. In addition, the data on the share of new competitive capacities are used in the block for calculating imports, influencing the elasticity of import relative to

[17] The rate of renewal of production capacities (and, correspondingly, the share of their competitive part) is determined, first, on the basis of the requirement for retirement of obsolete capacities, transition to the standard service life of equipment by the end of the forecast period; second, proceeding from the need to increase the efficiency of using the factors of production to maintain an acceptable level of profitability.

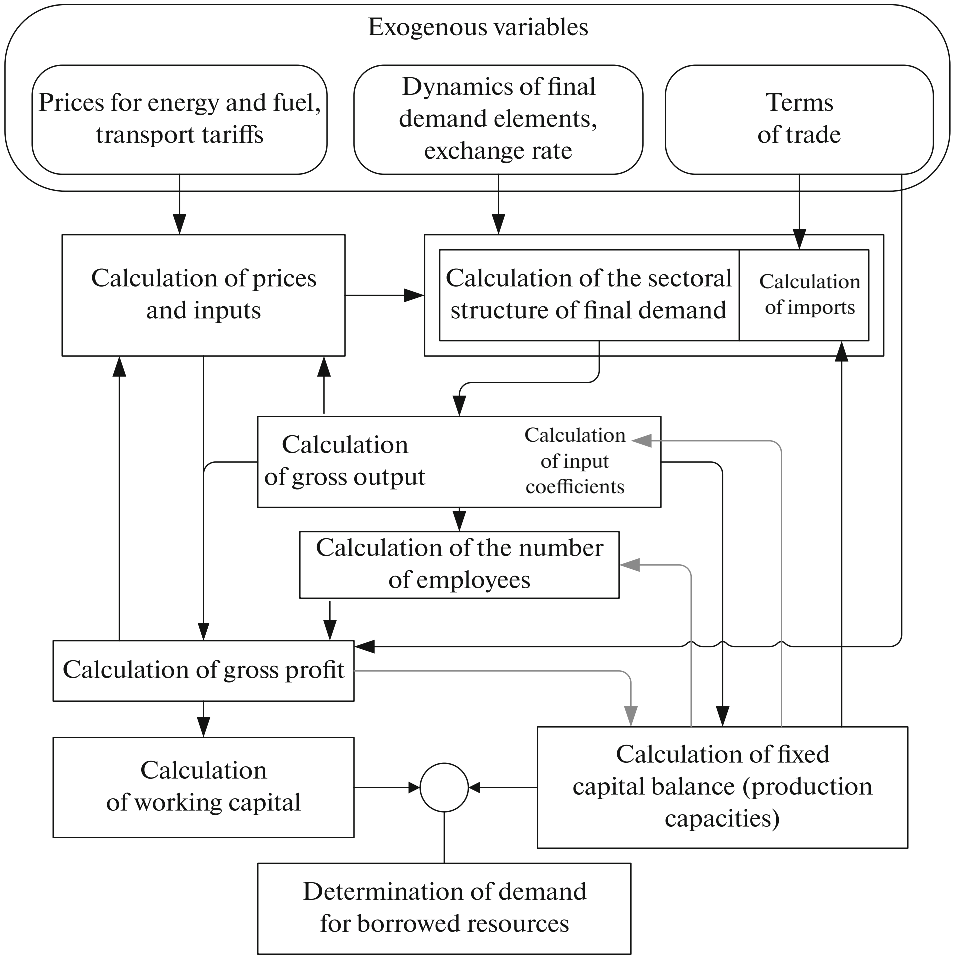

Fig. 1. Sequence of calculations in the model for forecasting the sectoral dynamics.

demand. The gross profit can also be calculated specifying the sectoral deflators and cost increase indices depending on a chosen scheme of calculations (two options): (1) fixed prices and the change in debt as the balancing element of financial balances; (2) fixed debt normatives and the change in prices as the balancing element.

The first version of the model (without the block for calculating the number of employees, with the simplified blocks for calculating production capacity balances) was developed in 2002 and was used for assessing the consequences of change in the level of tariff protection after the WTO accession[18]. Since then, the subsequent complicated versions of the model have been used on a continuing basis in all the research by CMASF (dozens of reports) that required the forecasts at a highly detailed sectoral level.

The IOT as a basis for assessing general economic and sectoral effects caused by the development of technology. CMASF began this work in 2009 started with the development of a methodology and model of the impact of technology on the key parameters of sector development and structural changes in the economy in the long term[19]. The model involved the use of assessing the three most important types of the impact of technologies on production processes: (1) the expansion or change of the resource base of production processes[20]; (2) the increase in the efficiency of the use and transformation of resources (including labor and capital), as well as making use of the addi-

[18] The work was performed by the request of the Higher School of Economics “Development of the Methodology and Construction of the Long-term Forecast of Economic Dynamics on the Basis of Detailed Input-Output Tables Making Allowance for the Conditions and Parameters of the Expected Russia’s Accession into the WTO”.

[19] As part of the implementation of phase II of the research work “Determination of the Factors of Competitiveness of the Leading Sectors of the Russian Economy and Ways to Improve It,” which was carried out in 2008–2009 under the State Contract No. 0208-18-08 as of September 23, 2008 (the Ministry of Economic Development of Russia).

tional properties of resources; (3) the improvement of existing consumer properties of finished products and services and creation of their new consumer properties. In turn, it was suggested that each type of impact should be reduced to a number of specific indicators of sector development that could be used in the models with IOT as the core. All three types of impact were assessed through the change in ICs. The second type could be additionally assessed by increasing labor productivity and reducing capital intensity (within the developed system for sectoral forecasting presented above). The third type could be additionally assessed through a wide range of indicators (changes in the "imports-resources" and "exports-output" ratios, the inflation-free growth in the unit value of exported products due to improvement in consumer properties, increase in elasticity of production to market dynamics, growth in per-unit final consumption, increase in the share of value added in the sector as a consequence of improvement in consumer properties). As a result, it becomes possible to assess value added created due to changes in certain indicators. In doing this, we developed the model for the redistribution of the additionally created value added to take multiplicative effects into account (an analog of the 4th quadrant of the IOT according to the System of Material Production). The distribution of additional increment in value added by each of the elements of final demand columns was performed using sectoral elasticities or based on more complex econometric models (developed within the system for sectoral forecasting).

Thus, the proposed approach made it possible to solve the problem of the transition from the estimates of changes in the ICs and other indicators to the estimates of production growth and distribution of value added. However, the problem of obtaining the initial estimates of changes in the ICs and other indicators due to the development of technology was only partially solved. At that stage of the work it was suggested that these direct effects should be assessed expertly, based on analyzing the retrospective statistics of the most technologically advanced countries (for this purpose, we analyzed the dynamics of the ICs for 35 activities and nine countries[21] for the period 1968–1990 and formed the "Retrospective Map of the Direction of Main Changes in the ICs" on this basis).

The approach was developed further in the research on long-term technological forecasting[22], in which the effects of technology development in the priority areas of science, technology, and engineering[23] were assessed by the pool of experts that evaluated the direct effects from the introduction of 33 types of such technologies, according to 3–6 indicators for each technology[24].

The same approach was applied by CMASF experts in the research on the assessment of the effects of digitalization (the further development and introduction of information and communication technology) in 2017[25]. Expert assessments of the direct effects of digitalization were refined and supplemented with the assessments of new effects, which had not previously received the proper attention[26].

The IOT as a tool for in-depth study of structural features of material production. After obtaining the first estimates of the 1st and 2nd detailed quadrants of the IOT, an in-depth study of the sectoral structure formed during transformational recession of 1990s was undertaken in 2000 at CMASF. The working concept of the study was the idea that this recession was accompanied by a break of the former economic ties (which became apparent in the strongest differentiation of output dynamics in individual sectors[27]) and separation of previously significantly technologically related sectors. Therefore, in order to analyze the structural features of industry, we proposed an alternative to the approach widely used at that time. We suggested to consider industry as a set of industrial and technological enclaves, i.e., groups of detailed sectors

[20]Obviously, an increase in the efficiency of using and converting resources (see the following type of the impact) can lead to shifts in the resource base of production processes. In this connection, this type of the impact is understood as the increase in the use of fundamentally new types of primary resources.

[21]Australia, Great Britain, Germany, Netherlands, Denmark, Canada, the United States, France, and Japan.

[22]The project "Scenario Analysis of the Impact of Russia's Scientific and Technological Development on the Macroeconomic Situation in the Long-term Outlook" under the Agreement on Granting a Subsidy No. 02.603.21.0003 (as of July 11, 2014) of the Ministry of Education and Science of Russia within the framework of the Federal Target Program "Research and Projects in the Priority Areas of the Development of Russia's Scientific and Technological Complex for 2014–2020".

[23]From the corresponding List that was approved by the Decree of the President of the Russian Federation as of July 7, 2011, No. 899.

[24]Thus, the total number of primary assessments was about one hundred and fifty.

[25]Within the framework of the research work on the theme: "Working Out the Strategy for the Development of the IT Ecosystem and Internet Entrepreneurship, Harmonization of the Strategy of the IT Ecosystem and Internet Entrepreneurship with the Strategy of the Internet Initiatives Development Foundation", which was performed at the request of the Foundation.

[26]For example, a decrease in the need for stocks due to their optimization, an increase in the efficiency of using fixed capital (due to the reduction of repair downtime), and so on.

[27]It suffices to say that the industrial output decreased by 55% in the period of 1991–1998, while the decrease was the least in gas production (15%), and the decrease in the most affected light industry was 89%. The main reason for this process was a sharp, shocking opening of foreign markets in the absence of any system-wide management of the process of involving the Russian economy in the world economy.

that satisfy at least two of the following three conditions: (a) the existence of significant industrial and technological links between the sectors of one enclave; (b) a common resource base, a similar set of main external supplier sectors; (c) a common use of inputs, sufficiently close structures of the distribution of production by the elements of both final and intermediate demand.

A total of 15 enclaves were identified in industry[28], which included 64 out of 83 industrial sectors under consideration. The complex description of the industrial and financial features of Russian industry at the turn of the 2000s was based on the analysis of production and technological enclaves (and their constituent sectors) and presented according to the following scheme: (a) the "portrait" of an enclave (its resource and technological characteristics, including the analysis of the scale of production, predominant orientation of the enclave to certain elements of intermediate and final demand, its structure, features of the resource base (cost structure), interrelations with other enclaves); (b) analysis of the dynamics of production in the enclave and its individual sectors in 1998–1999 and its factors; (c) analysis of the financial situation in the enclave[29].

Use of the IOT for modeling specific processes, as well as obtaining various auxiliary estimates. *The forecasting of producer price indices by economic activities* has been carried out at CMASF since the early 2000s. The forecasts were used both directly and indirectly, for the forecasts of financial balances of sectors and companies, for estimation of the effects of changes in prices and tariffs of natural monopolies, and in other work. The forecast of prices was based on the regression equations that took account of the factors such as increase in material costs, change in the ruble exchange rate, consumer price index, dynamics of world prices for key export goods, etc. For most types of economic activity, the main factor was the index of the increase in material costs. This index was calculated for each type of economic activity (it reflects an increase in the expenses on intermediate products of all economic activities that are used to make a final product). The calculation required the data on the wholesale price indices by economic activities and data from the 1st quadrant of the IOT (production and consumption of intermediate products):

$$IMZ_j = \sum_{i=1}^{n} X_{ij} IP_i \Big/ \sum_{i=1}^{n} X_{ij},$$

where i is the sector that supplies intermediate products; j is the sector that purchases intermediate products; n is the number of sectors; X_{ij} is the volume of the intermediate products of the sector i, which are purchased by the sector j; and IP_i is the index of wholesale prices for the sector i.

Determining the dependence of the Russian industry on imports of intermediate products. This dependence was assessed by CMASF in 2014 for the Ministry of Economic Development of the Russian Federation. This was necessary due to the fact that there were no official data on the IOT at that time (the publication of the Federal State Statistics Service appeared in March 2017), while the import matrix of IOT could be a basis for estimating the share of imports in the expenditures for raw materials and components. At the same time, calculating the dependence of industry on intermediate imports directly on the basis of the data from form No. 5-Z "Information on Costs of Production and Sales of Products (Goods, Works, and Services)"[30] (as proposed, for example, in [2]) was possible only for an incomplete range of enterprises; in addition, according to our estimates, these data were inaccurate[31].

We calculated the dependence of industry on intermediate imports as the ratio between imports of intermediate products and material costs[32] for each economic activity. We used the data from IOT to obtain the most correct estimate of intermediate imports as follows: (a) the data on the import of intermediate goods at the six-digit level of the CN FEA were aggregated into economic activities according to the nomenclature of the IOT (imports by supplier sectors)[33]; (b) the aggregated data on intermediate imports of each supplier sector were converted

[28] Extraction of fossil fuels, metallurgy, timber complex, export-oriented chemical production, internally oriented raw chemical production, production of chemical consumer goods, production of investment equipment, automotive industry, production of mobile machinery, high-tech engineering, production of construction materials, textile, clothing and footwear industry, production of basic foods, flavoring production, and production of alcohol drinks. The gross output of the sectors included in the enclaves amounted to approximately 80% of the total output of industrial products.

[29] The main results of this work were published in [1].

[30] Ratio between line 07 "expenses for purchasing imported raw materials and bought articles" and line 06 "expenses for purchasing raw materials, bought semifinished products, and components for the production and sale of products (goods, works, and services)".

[31] We have revealed that for some subsectors the share of import material costs, which was calculated according to form No. 5-Z as the product of this share and the volume of shipped products, may be several times less than the import purchases of certain goods (according to the data of the Federal Customs Service), which are used in the intermediate consumption of a sector.

[32] In this calculation, the denominator is the estimate of the volume of material costs for a full range of enterprises, which is obtained as the product of the volume of shipped goods for a full range of enterprises and the ratio of material costs to the volume of shipped goods for an incomplete set of enterprises (lines 06 and 01 of Form No. 5-Z).

through the 1st quadrant of the IOT into the estimate of intermediate imports by each purchasing sector.

Estimating the benefits from industrial cooperation in the EAEU. In 2014, by the request of the Eurasian Economic Commission, CMASF developed the methodology for assessing the effects of industrial cooperation within the framework of the Eurasian Economic Space (Belarus, Kazakhstan, and Russia) due to the increase in mutual trade in intermediate products (see [3]). The key factor of the effect in the model is substitution of intermediate goods produced in country *A* by analogous goods from its partner countries from the integration union, which should cause an improvement in the consumer properties of finished goods produced in country *A*. Of course, the substitution takes place only if the consumer properties of intermediate products in the partner countries are better than in country *A*. The assessment was carried out as follows: (a) the consumer properties of products for each sector and country were approximated by Balassa index of comparative advantages (the share of the sector in exports relative to the world average); (b) it was assumed that country *A* would increase imports of intermediate products from partner countries in the sectors with higher Balassa index for partner countries, and thus it would gain access to more qualitative components for the production of finished products (an improvement in the consumer properties of intermediate products was assessed); (c) the data from IOT were used to assess the extent to which the improvement in the consumer properties of intermediate goods will be transformed into the improvement in the consumer properties of finished products (for this purpose, the dynamics of Balassa index for each economic activity was compared with the dynamics of the weighted average Balassa index for the activities that made up the inputs for this activity).

Assessment of integration effects making allowance for the technological interrelation of goods. In 2015–2017, for the purposes of the Eurasian Economic Commission (EEC), CMASF developed the methodology for estimating the integration potential in terms of export growth (see also [4]) and import substitution [5]. The methodology was a modification of the well-known approach to estimating the export potential by commodity groups, which was proposed in [6] as early as in the mid-2000s by R. Hausmann and B. Klinger. The logic of this approach implied that a country's exports grow faster for those goods that are the closest to its current export basket (i.e., the goods that are most often exported by other countries jointly with the leading export goods of the analyzed country).

An important element of this modification was the use of the input-output data to control the adequacy of the results. The two products were marked as interrelated only in case of the high frequency of their joint exportation by different countries and the moderate degree of technological connection, i.e., the maximal of the input coefficients from IOT for the corresponding sectors had to exceed 0.02[34]. The estimate was carried out at the 4- and 6-digit levels of the CN FEA, so it was fundamentally important to use a highly detailed IOT for this kind of research[35].

Redistribution of benefits from integration in the EAEU due to multiplicative effects. In 2016–2017, by the request of the EEC, CMASF developed the methodology for assessing the integration potential by economic activities in terms of output and value added created by multiplicative effects (through the IOT). The input data were the volumes of growth in net exports as a result of integration processes, which were obtained by using the methods for estimating the integration potential in terms of export growth and import substitution. When the official IOT appeared in March 2017, we presented the updated estimates based on new data and published them in [7]. We estimated the distribution of benefits in terms of output and value added as follows: (a) the vector of growth in the output of supplier sectors was defined as the product of the Leontief inverse matrix and the vector of growth in net exports due to integration; (b) the vector of growth in value added was estimated using the elementwise multiplication of the output growth vector by the vector of the value added share in the output. According to the results, the benefits of integration were redistributed extremely unevenly: for example, machinery accounted for about 30% of the integration potential in terms of foreign trade, but only 15% in terms of value-added. Using the IOT, we have shown that a significant portion of the direct gain from foreign trade (growth in net exports) was redistributed into services (wholesale trade, land transport, leasing, financial activities) and mining.

[33] In 2017, the Ministry of Economic Development of the Russian Federation published the correspondence tables between the Commodity Nomenclature for Foreign Economic Activities of the Eurasian Economic Union (CN FEA EAEU) and the All-Russian Classification of Products by Economic Activities (OKPD2). Up to this moment, there were no official correspondence tables, and, therefore, in order to fulfill the task of aggregating the data on intermediate imports, we conducted an additional large-scale work on establishing a correspondence between the codes of the CN FEA and economic activities according to the IOT at a detailed level.

[34] The threshold was determined empirically, based on the coverage of the volume of intermediate consumption of 75%.

[35] Approximately 1200 commodity groups are distinguished at the four-digit level of the CN FEA, and approximately 5000 groups are distinguished at the six-digit level.

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