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CONSTRUCTING RETROSPECTIVE TIME SERIES OF RUSSIAN INPUT-OUTPUT ACCOUNTS BASED ON THE NACE/CPA CLASSIFICATIONS[5]

Time series of Input-Output (IO) accounts at current and constant prices are widely applied to study the dynamics and structure of economic activity within country and conduct cross-country comparisons and analyses of globalization processes as well as their impacts. For these purposes IO accounts have to adhere to a uniform nomenclature of products and economic activities in accordance with international standards. Unfortunately, Russian statistics currently do not satisfy this condition. The first Russian IO accounts for 2011, built in accordance with international standards, will be published only at the end of 2015 (previously published tables for 1995-2003 were built in the classifications "inherited" from the Soviet period). The IO accounts for 2012 and subsequent years will be built by extrapolating the cost structure of products and services for 2011. However, it leaves the open question of extending the time series of these tables for the retrospective period prior to 2011. As international experience shows, this type of calculation was predominantly conducted by research organizations and universities. Given this, the National Research University Higher School of Economics has been developing a methodology for constructing a retrospective time series of a part of the IO accounts (use tables and valuation matrices) from 2010, in order to experimentally test them, and apply them to the official IO accounts for 2011. The following results were obtained from our study. First, we proposed a two-step procedure to transform IO accounts for 2003 from the Soviet into the OKVED/OKPD classifications. Second, we used a two-stage biproportional method generalizing the RAS procedure to construct a time series of IO accounts for the subsequent period using the 2003 transformed IO accounts as the starting point. Finally, we recalculated a part of the IO accounts (use tables) at the previous year prices.

JEL Classification: C67, C82, D57

Keywords: Input-Output Accounts, Soviet classifications, NACE rev.1, CPA, time series, RAS, matrix balancing

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Introduction

Input-Output (IO) accounts have broad statistical and analytical applications. As an inherent part of the System of National Accounts (SNA), IO accounts allow for the integration and harmonization of the indicators in terms of their economic content, product, and industry classifications. As a consequence, they improve the quality of the SNA's indicators. In addition to the statistical values, IO accounts are an essential tool for economic analysis and forecasting [Eurostat, 2008, ch. 15], [Miller & Blair, 2009]. In accordance with the methodology of the SNA, IO accounts include the following tables: the supply table, the use table of domestically produced goods at basic prices, the use table of imports at basic prices, the symmetric input-output table, valuation matrices such as trade and transport margin matrices, as well as matrices for net taxes on products. There are benchmark and annual IO accounts. Benchmark IO accounts are usually constructed once every five years for detailed economic activities, products and services based on surveys of establishments from different industries. For the intermediate years between the developments of the benchmark IO accounts, annual accounts are constructed in a more aggregated nomenclature. Thus, time series of IO accounts for a relatively long period are formed. These series must comply with the uniform format of the industry and product classifications, the format of tables, and the methodology of constructing them at current and constant prices.

Statistical agencies and research organizations within the USSR have gathered considerable experience in constructing IO accounts (inter-industry balances) and using them for planning and forecasting activities. This experience has served as a precondition for the continued construction of IO accounts in the Russian Federation in the post-Soviet period. The Russian Federal State Statistical Service (Rosstat) developed benchmark IO accounts for 1995, and annual IO accounts for the period from 1996 to 2003 at current prices in accordance with the methodology for the SNA, adopted by the United Nations (UN). IO accounts for 1996-2003 were built by extrapolating the cost structure of products and services for 1995 based on the SNA indicators for Russia. However, these time series of IO accounts were constructed based on classifications of products and industries inherited from the Soviet period, namely, the All-Union Classifier of Economic Branches (OKONH) and the All-Union Product Nomenclature (OKP). Rosstat did not carry out the construction of IO accounts at constant prices because of measurement problems due to the transitioning economy, as well as a lack of resources.

Since 2004, the transition of Russian statistics to the All-Russian Classification System of Economic Production (OKVED) harmonized with the NACE rev.1 classification and the All-Russian Classifier of Products by Activity (OKPD) harmonized with the CPA classification has led to a break in the construction of IO accounts[6]. The first Russian IO accounts for 2011 based on NACE rev.1/CPA have to be published in late 2015. The supply and use tables for 2012 and subsequent years will be built by extrapolating the cost structure of products and services for 2011. However, it leaves the open question of extending the time series of these tables for the retrospective period prior to 2011. Meanwhile, restoration of long time series of IO accounts is particularly important in light of the fact that it significantly expands the possibility of the analysis of economic dynamics.

The transformation of previously constructed IO accounts based on the Soviet classification into the new classifications is quite a challenge. Ideally it requires the construction of transformation matrices with quantitative proportions between the indicators in the old and new classifications drawn up on the basis of microdata received from establishments in both old and new classifications. However, the cost of collecting baseline data in this format is extremely high and this approach is almost never used[7].

As international experience shows, due to these difficulties this type of calculation was predominantly conducted by research organizations and universities. Prominent initiatives in the construction of the IO database were introduced by OECD (OECD Inter-Country Input-Output (ICIO) Tables[8], the Purdue University (Global Trade Analysis Project)[9], the University of Sydney (The Eora multi-region IO database)[10], et al. We briefly review two of these international databases which contain tables for the period of interest to us, from 2003 to 2011: the World Input-Output Database (WIOD) project and the Global Trade Analysis Project (GTAP). An international project to develop the WIOD was carried out by a consortium of international organizations and leading European universities. As part of the WIOD project, an approach to constructing a time series of IO accounts based on the NACE rev. 1/CPA classifications was proposed [Timmer (eds.), 2012]. A time series was developed of supply and use tables at current and previous year prices for 35 industries and 59 types of products, as well as symmetric input-

6 Furthermore, for convenience we will use NACE rev.1/CPA instead of the corresponding Russian classifications OKVED/OKPD. Indeed, although the OKVED classification is based on activities and the NACE rev. 1 classification is implemented by industries, the activity and the industry are the same in practice.

7 An exception is the Canadian experience: benchmark symmetric tables for 1997 were built both in the SIC and NAICS classifications. The resulting transformation matrix from the SIC industries to NAICS industry was used to transform quadrants I and III of previously published symmetric tables at the level of 119 industries and 476 products for the period from 1961 to 1996 [Trau & Girard, 2004].

8 See [http://www.oecd.org/sti/ind/input-outputtables.htm].

9 See [https://www.gtap.agecon.purdue.edu].

10 See [http://www.worldmrio.com].

output tables at current prices for 35 industries in the Russian Federation for the period from 1995 to 2011 [Erumban et al., 2012]. To create a time a series of supply and use tables for Russia, developers used detailed benchmark IO for 1995 recalculated from the OKONH to the NACE rev.1 classifications using the official transformation factor: OKONH/OKVED harmonized with the NACE rev.1 classification [The Ministry of Economic Development, 2002]. Then, on the basis of the transformed IO accounts, they constructed a time series of supply and use tables using modern methods of balancing and constructing time series, SUT-RAS [Temurshoev & Timmer, 2011].

Compliance with methodological uniformity in terms of harmonization and standardization, as well as in the procedures for constructing a time series of national IO accounts, not only guarantee the compatibility of the WIOD database among different countries but also expands its analytical capacity. However, such methodological unification does not always consider the measurement specifics of countries with economies in transition. Meanwhile, measurement problems in countries with economies in transition are exacerbated sharply compared to countries with more stable economies. In particular, the transition process in Russia is characterized by high inflation (over the entire reform period, prices rose by five orders of magnitude), large-scale changes in relative prices and an extremely deep and prolonged transformational recession, followed by an intensive recovery and growth [Bessonov, 2005]. Therefore, calculations of IO accounts for the period from 1995 to 2011 using the proportions of 1995 will inevitably lead to a shift in inter-industry proportions. These displacements become larger with the passage of more and more time after 1995. Measurement problems inherent in a transitional economy are added to purely statistical difficulties including a lack of totals from the SNA based on the NACE rev. 1/CPA classifications for supply and use tables for the period before 2002, as well as frequent methodological changes and other statistical innovations.

In contrast with the WIOD project, in which developers take the initiative in forming the database, participation in the GTAP fulfills certain requirements in terms of statistical data from the participating countries themselves. For Russia’s participation in the GTAP, the Centre for Economic and Financial Research (CEFIR) prepared a database of IO accounts for 2003 based on the ISIC rev.3/CPA classifications for Russia [Tourdyeva & Shrebela, 2008]. For this purpose, they transformed and disaggregated officially published symmetric input-output tables for 2003 from 22 to 59 types of goods and services, and subsequently adjusted to the GTAP format. Recalculation and disaggregation of the symmetric table were performed using the same official transformation factor and a symmetric input-output table for 1995 as in the WIOD project.

However, in these investigations the authors use the official concordance tables, which can only be employed for situations where one NACE rev. 1 activity corresponds to one or more industries based on the Soviet classification. In cases where an OKONH industry is distributed among several NACE rev. 1 activities, there is a need to identify the quantitative proportions of the distribution between the codes within these classifications. However, the NACE rev. 1 information necessary for carrying out this procedure for 1995 is missing. Therefore, we can assume that in order to transform IO accounts into new classifications, our foreign and Russian colleagues would inevitably have been forced to derive such quantitative proportions using *a priori* considerations. As is evident from the WIOD tables on the Russian Federation, they likely considered in all cases that an industry based on the OKONH classification corresponded to only one type of activity based on the NACE rev.1 classification, which is not always the case[11].

Another problem in the database construction for Russia is that information constraints forced developers to use simplistic assumptions in the construction of indicators and tables. For example, simplistic approaches were used in the construction of valuation matrices, trade and transport margins in the WIOD methodology [Timmer (eds.), 2012, p.22-23].

Russian experts handled the construction of the IO account based on the NACE rev.1/CPA for Russia. The Institute of Macroeconomic Analysis under the Ministry of Economic Development of the Russian Federation (IMA) built a time series of IO accounts based on the NACE rev.1/CPA classifications for the period for 2007 and subsequent years without using the Rosstat tables based on the old classifications [Kashirskaya, 2012]. The time series of IMA's tables are intended for internal use only. Furthermore, due to the lack of benchmark tables based on NACE rev.1/CPA, it is difficult to estimate the validity of the results. The Institute of Economic Forecasting of the Russian Academy of Sciences, IEF RAS, specializing in macroeconomic analysis and forecasting also built its own estimates of IO accounts based on the Soviet classifications – OKONH/OKP – for the period after 2003[12]. However, after economic departments and agencies transferred to the new classifications, it became difficult to compare the estimated macroeconomic indicators based on the OKONH/OKP with the officially published indicators based on the NACE rev.1/CPA.

Meanwhile, the development of the SNA in Russia, including the construction of detailed production accounts based on the NACE rev.1 by Rosstat, and the accumulation of unpublished data from Rosstat, created the prerequisites necessary to derive IO accounts based on NACE rev.1/CPA for 2003-2010.

[11]See [http://www.wiod.org].
[12] See [http://www.macroforecast.ru].

This study was initiated at the National Research University Higher School of Economics (NRU HSE) in 2010. In 2012-2013 the research was conducted in conjunction with IMA. In our study we selected 2003 as the starting point for the transformation of IO accounts into new classifications because the minimum necessary information to develop reliable transformation matrices containing quantitative proportions between OKONH and NACE rev.1 classifications is only available for that year.

As Rosstat is developing a time series of production matrix (one part of the supply table) in aggregate format based on the new classifications [Rosstat, 2011], [Rosstat, 2012], in this paper, we focus on the transformation into the new classifications of only five use tables (domestic production at basic prices, imports at basic prices, valuation matrices for trade margins, transport margins and net taxes on products), which comprise the use table at purchasers' prices[13]. To obtain the use tables and valuation matrices based on the new classifications, we apply a two-stage procedure using data for 2003. First, we develop a suitable disaggregation procedure to construct the five disaggregated tables based on the Soviet classifications (95 activities by 127 products). Second, we transform these disaggregated tables into NACE rev.1/CPA classifications. Then, we use transformed tables for 2003 as the basis for constructing a time series of use tables and valuation matrices for 2004 and subsequent years.

The degree of detailed unpublished data on the OKONH basis and detailed data on the production account allow us to obtain use tables at basic prices and valuation matrices on a NACE rev.1/CPA basis for 42 types of commodities and economic activities [see Appendix A].

Our paper has the following structure: Section 1 presents the main methodological problems associated with the transformation of use tables and valuation matrices for 2003 from the Soviet classifications into the NACE rev.1/CPA. Section 2 describes a two-step procedure for conducting this transformation. Section 3 provides an algorithm for constructing a time series of use tables and valuation matrices at current prices based on transformed tables for 2003, as well as a description of our procedure for recalculation of these tables at the previous year prices. In the conclusion, we summarize our results and suggest the main areas for further research. A detailed formal description of the disaggregation algorithm is given in Appendix B.

[13] In this paper, we do not transform the symmetric (product by product) tables from the old to the new classifications because symmetrical table are calculated on the basis of supply and use tables.

1. The main methodological problems

In the transformation of use tables and valuation matrices for 2003 from the Soviet Classifications into NACE rev.1/CPA classifications, we face a number of methodological difficulties:

- For each of the initial five tables, there must be transformation matrices to transform use tables and valuation matrices from OKONH/OKP to the NACE rev.1/CPA separately for the matrix of intermediate consumption and matrix of final demand. Transformation matrices have to involve the numerical values. The approach is motivated by the fundamental differences between the Soviet and NACE rev.1 classifications and considerable changes in the indicators of output, intermediate consumption and value added from the production account as a whole for 2003, as well as in the detailed classification. These changes in the indicators can be explained not only by the reclassification of the sector profile of establishments, but also by changes in the calculations in the methodology. Moreover, the more detailed the nomenclature of the tables, the more reliable the appropriate transformation matrices will be.
- Under the retrospective transformation of the production account for 2003 into NACE rev.1 for some activities, Rosstat has significantly revised indicators of the output, intermediate consumption and value added. In addition, the aggregates of intermediate consumption and value added based on NACE rev.1 do no match these aggregates based on OKONH [Baranov et al., 2013, p.4].
- The methodological changes regarding the treatment of financial intermediation services indirectly measured (FISIM) in use tables are taken into account. FISIM are allocated across activities. After the adjustment with respect to common concepts, the intermediate consumption by type of activity increases by an average of 1.5–2%.

2. The procedure for the transformation of use tables and valuation matrices from the Soviet classifications into the NACE rev.1/CPA classifications

For transformation of use tables and valuation matrices from the Soviet classifications into the NACE rev.1/CPA we use the following data:

- The last officially published IO accounts (use table of domestic production, use tables of imports, valuation matrices for trade margins, transport margins and net taxes on products which add up to use table at purchasers’ prices) based on the Soviet classifications for 24 groups of industries and products for 2003 [Rosstat, 2006].

- Unpublished detailed use table at purchasers' prices based on Soviet classifications for 2003.
- Detailed data for production accounts at the level of 72 activities as well as elements of GDP under the expenditures approach based on the NACE rev.1 for 2003 [Rosstat, 2011].
- Unpublished detailed production matrix based on NACE rev.1 for 2003.

To construct vectors of net taxes on products, transport and trade margins for 2003, we apply vectors of net taxes on products, transport and trade margins for 2004 (provided by Rosstat), which are then translated into estimates for 2003 that are given the structure of the data from 2004.

In addition, detailed (10-digit HS codes) customs statistics collected and rearranged from 10-digit harmonization system (HS) codes of the Foreign Economic Activity Commodity Classification in the structure of CPA by IMA, as well as statistics from the Bank of Russia are used to calculate the vector of imports by goods and services for 2003 and subsequent years[14].

These vectors as well as the vector of total domestic output at basic prices from the production matrix are an aggregated version of these variables which represent full size use table of domestic production, use table of imports, matrices of net taxes and margins that have to be assessed for the overall compilation of the input-output framework [Eurostat, 2008, p.88. fig. 4.2].

To build sufficient reliable transformation matrices there is a need to breakdown the detailed use table into its five components so that after aggregating these five tables, they will be found to be equal to the official aggregated tables. For this purpose we developed a two-step procedure.

In the first step, we disaggregated a detailed, unpublished use table at purchasers' prices based on OKONH into its five components (the matrices of intermediate consumption and final demand of each table contains 95 rows and 127 columns) using official data on use tables and valuation matrices as restrictions (the matrices of intermediate consumption and final demand of each table contains 24 rows and 34 columns). Then we simultaneously balanced these matrices of all five calculated tables. To accomplish this, we used the GRAS algorithm by [Junius &

[14] Customs statistics do not contain data on informal trade as well as imports and exports of services. Selected estimates of import and export services at an aggregated level are contained in data on foreign economic activities that were collected by the Central Bank of the Russian Federation. With regard to the value of the informal trade of imported goods, the bulk of it is represented by light industry goods and automobiles. Thus we have made relevant expert amendments to the values for the imports of services and informal trade.

Oosterhaven, 2003] in the version of [Lenzen et al., 2009, subsection 3.1]. For the formal description of the method used see Appendix B.

In the second step we transformed disaggregated and balanced tables from the Soviet classification into the NACE rev.1/CPA. This transformation was carried out for each of the tables separately for the matrix of intermediate consumption and the matrix of final demand using appropriate transformation matrices. The transformation matrices for the use table of domestic production was developed using detailed data on the production of hundreds of specific products in 2002. For non-industrial activities, data on the outputs of products and services in the detailed nomenclature of NACE rev. 1 from 2004 was used. The transformation matrices for the use table of imports was developed using detailed data on imports from the Federal Customs Service and the Bank of Russia. We did not have the necessary information to develop transformation matrices for valuation matrices. Thus in order to transform disaggregated valuation matrices into NACE rev.1/CPA we used the ratio of the elements of valuation matrices to the sum of the elements of use tables of domestic production and imports in Soviet classifications and transformation matrices for use table of domestic production and use table of imports. The technique is described in [Baranov et al., 2013, pp. 6-8, 10-11].

In order to ensure consistency between the totals of transformed IO accounts with SNA aggregates a final balancing of all transformed tables was carried out using a version of GRAS.

3. Methodology of construction of time series of use tables and valuation matrices at current and previous year prices

3.1. Sequence of procedures for the construction of the use tables and valuation matrices at current prices for 2004 and subsequent years

In the most common formulation, the mathematical model for constructing input-output matrices given the known initial matrices from the previous year – projection – involves finding the unknown interior elements of the matrix **X** for the target year on the basis of the initial matrix **A** for the previous year and known totals by row and column of matrix **X** (Figure 1).

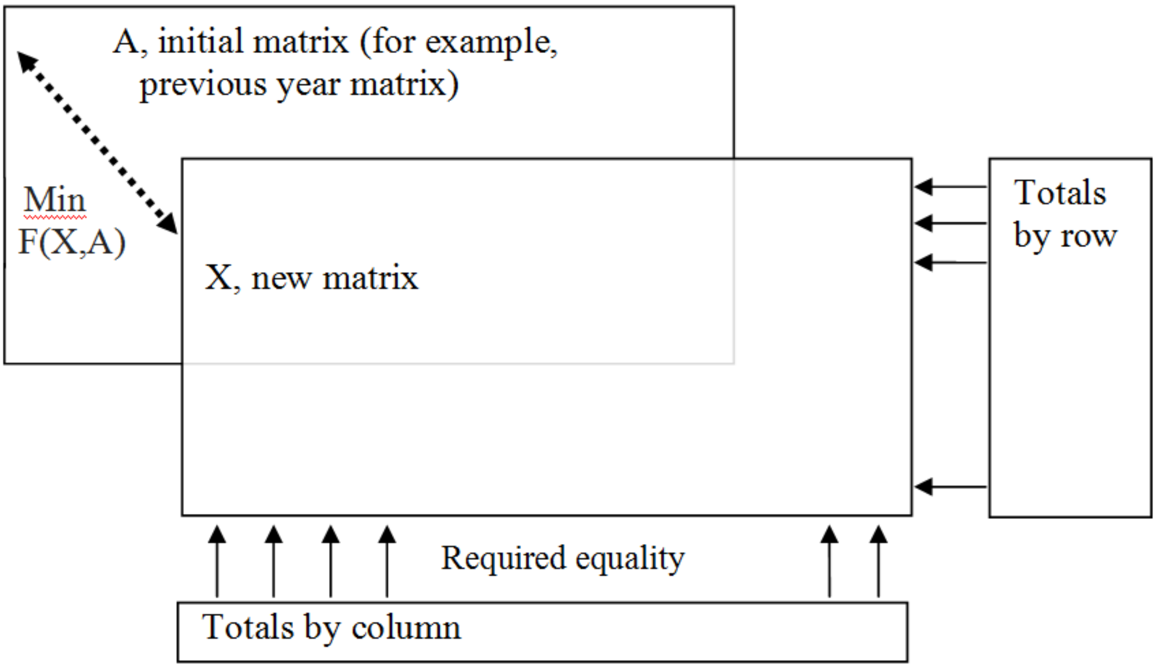

Fig. 1. The scheme for the construction of the new matrix **X** at the target year, on the basis of the initial matrix **A** at year t and known output totals at the target year.

In this projection task, the matrix of intermediate consumption for a different period of time is usually used as the initial matrix. The challenge is in getting the resulting matrix **X** as close as possible to the original matrix with the totals by row and column equal to the specified new totals [Miller & Blair, 2009, ch.7]. In our case, the use of the classical RAS procedure to construct a time series of use tables and valuation matrices is difficult because there is no information to adequately determine the total intermediate uses by row for 2004 and subsequent years. Therefore, in this research, taking into account the fact that for 2004 and subsequent years it may be possible to establish reliable summary totals by row for the matrix of intermediate consumption and the matrix of final demand, the RAS procedure was applied to rectangular matrices, comprising both intermediate consumption and final demand.

To construct time series of use tables and valuation matrices based on NACE rev.1/CPA we used the following official and unpublished data:

- Detailed data for production accounts and use components of the GDP under the expenditures approach based on the NACE rev.1 for 2004 and subsequent years [Rosstat, 2011].
- Unpublished production matrix for 2004 and subsequent years at disaggregated nomenclatures based on NACE rev.1/CPA classifications, as well as an earlier version of the supply table at purchasers' prices based on NACE rev.1/CPA for 2004 (which includes a

production matrix at basic prices, an import matrix represented by the vectors of imports and CIF/FOB adjustments, vectors of transport and trade margins and net taxes on products).

It should be noted that for 2005 and subsequent years we no longer have Rosstat’s information about the import matrix and the valuation vectors. Thus we were forced to construct them ourselves by analogy with vectors for 2003.

The construction of IO accounts for 2004 and subsequent years on the basis of IO accounts for 2003 requires a mandatory execution of at least three conditions:

- Equality between the totals of IO accounts and corresponding indicators in the SNA,
- Equality between the individual elements in the final expenditures of the use table at purchasers' prices and corresponding elements from the unpublished detailed data from Rosstat, and
- Equality between elements in exports of products (for most items) and the indicators of exports transformed from Foreign Economic Activity Commodity Nomenclature into CPA.

The procedure for the construction of a time series was carried out in the following sequence.

In the first step, we manually constructed valuation vectors represented by trade and transport margins and net taxes on products, as well as vectors of imports and CIF/FOB adjustments based on CPA. These vectors as well as the vector of total domestic output at basic prices from a production matrix are an aggregated version of these variables which represent a full size use table of domestic production, use table of imports, matrices of net taxes and margins that have to be assessed for the overall compilation of the input-output framework [Eurostat, 2008, p.88. fig. 4.2].

Figure 2 provides a general scheme for the construction of a coherent matrix of intermediate consumption and final demand matrix of each of the five tables.

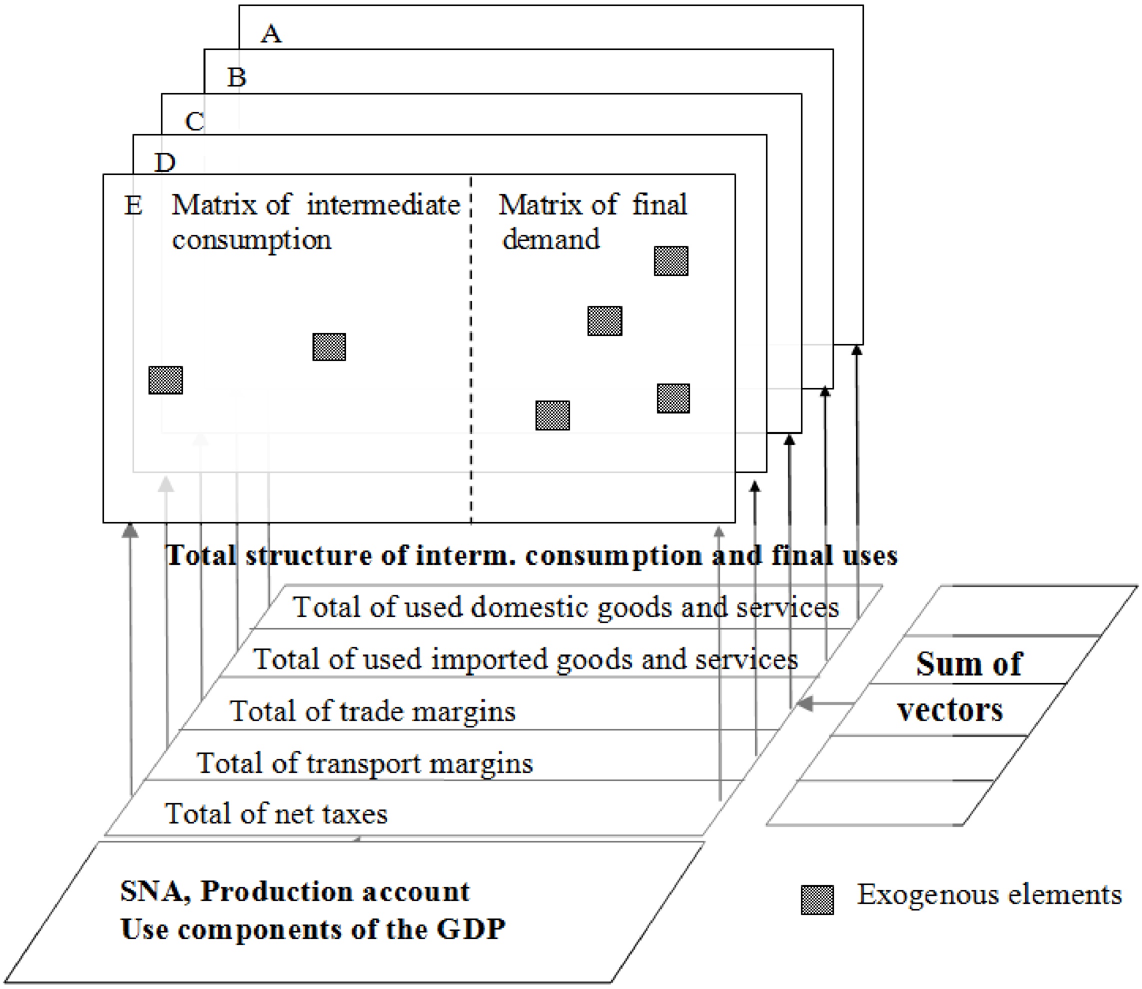

Fig. 2. Compilation of a structure defined by the totals of the intermediate consumption by industry and totals of final uses by category at purchasers' prices for 2003 on the basis of the use table of domestically produced goods at basic prices (Table A), the use table of imports at basic prices (Table B), matrix of trade margins matrices (Table C), matrix of transport margins (Table D) and matrix of net taxes on products (Table E).

In the second step, we calculated the rows of the total of intermediate consumption by activity and total final uses by category for each of the five tables which add up to the use table at purchasers' prices for the period since 2004.

Calculations were performed by applying the RAS procedure. The compiled structure of the total intermediate consumption by activity and total final uses by category of the transformed use table of domestically produced goods at basic prices, the use table of imports at basic prices and the three valuation matrices for 2003 was considered as the initial matrix. The total of intermediate consumption by activity and the final uses by category for subsequent years were taken from the detailed production account and GDP expenditure approach. Totals by row for subsequent years were determined as the sum of the elements of each vector, which were calculated at the first step. In Figure 2, the row vector of corresponding margins (totals) is represented by "SNA, production account, Use components of the GDP", the column vector – by "Sum of vectors".

The result of the calculations received in the second step is represented in Table 1 and shown as "Total structure of intermediate consumption and final uses" in Figure 2.

Tab. 1. Structure of totals of intermediate consumption by activity and final uses by category

	by Activity				by Final uses				Total
	1	…	…	*n*	*n+1*	…	…	*n+k*	
Total of used domestic goods and services	A								
Total of used imported goods and services	B								
Total of trade margins	C								
Total of transport margins	D								
Total of net taxes	E								
Total intermediate consumption and final uses at purchasers' prices	A+B+C+D+E								

In step three, in accordance with our proposed approach, we simultaneously compiled the matrix of intermediate consumption and the matrix of final demand of these five tables applying the RAS method. The matrix of intermediate consumption and matrix of final demand of use tables at basic prices, and valuations matrices for 2003, were used as prior matrices, the column and row totals for subsequent years were obtained in the previous two steps.

The procedure for constructing the valuation matrix of net taxes on products has some more features. The initial table of net taxes for 2003 contains 14 negative elements and totals by row. Negative elements in the valuation matrix of net taxes on products indicate that the subsidies exceed the taxes on products. In data for 2003, the negative values are associated with agriculture (subsidies for seeds, fertilizers, etc.) and its use in the manufacturing of food products, as well as the subsidy on household consumption in housing and public utilities and the social services. The remaining negative elements represent a reduction in the inventories; these elements are very insignificant in magnitude. According to official data since 2003, the size of subsidies has declined; however, their indicators vary from year to year, so such a trend is not captured by the RAS method and its modifications. Thus these negative elements were defined exogenously using statistical reporting (these elements are shown schematically as gray squares in Figure 2).

Then we applied the approach of [Paelinck & Waelbroeck, 1963] to estimate the time series of the valuation matrix of net taxes. For this purpose we account for the values of known interior cells of the table of net taxes by setting the particular known cell values to zero and subtracting the known values from the corresponding totals. Finally, after obtaining the solution by applying the RAS procedure, we placed the known values back into their cells and added them to the corresponding totals.

At the final stage of the calculation we constructed the use table at current purchasers' prices (as the sum of the Tables A, B, C, D and E, Figure 2), and the use table at current basic prices (as the sum of the Tables A and B in Figure. 2). In international practice an alternative approach is used. This implies that firstly the table at purchasers' prices is obtained, and then it is broken down into its components at basic prices. For example, in [Simpson, 2007] this approach is recommended for export. However, we do not use it because of the properties of the RAS method (strictly proportional updating of the transactions of each table from the previous year). In such a situation, the elements of the table at purchasers' prices could not be reconciled with the sum of the corresponding elements of the constituent tables.

3.2. Constructing of use tables for 2004 and subsequent years at previous year prices

From a methodological point of view, the deflators needed for constructing use tables at the previous year's prices should be calculated from the monthly Producer Price Index (PPI) data. However, Rosstat's data covers mostly price indices for goods (and these indexes are too aggregated), while for services only transport and communication indexes are available. Therefore, as an alternative approach, we derived implicit deflators from the SNA, dividing the nominal output growth rates by the real ones for the detailed range of economic activities.

Although the deflators calculated with this procedure correspond to industries, we actually need deflators for products. We believe that this is acceptable as a first approximation, because outputs for the detailed set of industries and their products do not differ greatly (particularly, according to the 2004 data). For most issues the share of primary product in an industry's output exceeds 90%, and the lowest value is more than 80%.

For the construction of import deflators additional information was used. For goods, we rearranged into our own nomenclature the customs statistics data in 10-digit codes of the Foreign Economic Activity Commodity Nomenclature, regrouped to CPA by IMA. That data is available in USD values and in volumes, so annual import deflators in USD could be calculated by dividing their year to year change rates. Then values in USD were multiplied by the average annual variation in USD/RUR exchange rate to convert them into rubles. For the import of services we used as deflators rates of inflation in the European Union [https://www.ereport.ru/stat.php], as it is the biggest Russian counterpart in service trade (approximately 40% of total volume in 2004 and 2005).

Since the nomenclature of our use tables is sufficiently aggregated, the composition of the detailed products and services can vary significantly for different cells of one row, depending on the exact cost structure of each element. Thus, the deflators should be different for each cell instead of being uniform for the whole row. Unfortunately, we did not have enough information to implement such a differentiation and were forced to use a single deflator for each row.

The conversion of use table for domestic goods and services for 2004 and subsequent years from current prices to previous year prices was implemented by dividing all the elements of each row of the table by the corresponding deflator. Purchases on the domestic territory by non-residents, subtracted from the household's final consumption, were converted using the household final consumption deflator from the SNA (as a first approximation).

Similarly, the conversion of use tables for the import of goods and services for 2004 and subsequent years to previous year prices was implemented by dividing all the elements of each row of the table by the corresponding import deflator. Direct purchases abroad by residents were converted using the common import deflator from the SNA (as a first approximation).

The matrix summation of use tables for domestic and imported goods and services gives a use table in previous year prices. Similar procedures were used for the all following years.

Conclusion

This research leads to the following results:

- We have developed a methodology for the transformation of use tables at basic prices and valuation matrices that were published based on Soviet classifications for 2003 into the NACE rev. 1/CPA classifications.
- We have used a two-stage biproportional method generalizing the RAS procedure for the projection of use tables and valuation matrices for 2004 and subsequent years based on the use tables and valuation matrices for 2003.

The methodology and the scheme of constructing a time series of IO accounts presented in this paper has been experimentally verified in a joint work of the authors and colleagues from the IMA: a time series of IO accounts based on the NACE rev.1/CPA at current and previous year prices for Russia for the period from 2003 to 2006 have been developed. Overall, preliminary results have been considered satisfactory. Nevertheless, we would highlight the need to adjust the transformation matrices from the Soviet OKP to the CPA classification by elements of final demand in order to obtain more reliable "quasi-benchmark" IO accounts for 2003. Note also that choosing the effectiveness of the generalized GRAS algorithm – in comparison with other balancing methods, for our purpose of simultaneous balancing the five disaggregated tables (at the stage of transformation of tables into the new classifications) – needs additional empirical support. We refer the reader to a subsequent forthcoming paper for such an empirical study based on numerical experiments with further aggregation of the five use tables.

Further research priorities include:

- The testing of different projection methods apart from RAS to select the most preferred for a Russian context;
- Examining backward projection possibilities for the period prior to 2003 (considering the absence of official Rosstat SNA data in the NACE rev.1 for this period).

After the publication of detailed Russian IO accounts for 2011 by Rosstat (planned in December, 2015), our time series needs to be reconciled with the interpolation by both the 2003 and 2011 bases.

Appendix A

Classification of the Russian IO accounts for 2003 according to NACE rev.1

01	Agriculture
02	Forestry
05	Fishing
10	Mining of coal and lignite; extraction of peat
11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying
12+13+14	Other mining
15+16	Manufacture of food products and beverages; Manufacture of tobacco products
17+18	Manufacture of textiles; manufacture of wearing apparel
19	Manufacture of leather and leather products; manufacture of footwear
20	Manufacture of wood and of products of wood
21	Manufacture of pulp, paper and paper products
22.1	Publishing
22.2+22.3	Printing and service activities related to printing Reproduction of recorded media
23.1+23.2	Manufacture of coke and refined petroleum products
24 except 24.61	Manufacture of chemicals and chemical products, except explosives
24.4	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral products
27+28	Manufacture of basic metals; manufacture of other non-metallic mineral products
29 except 29.6	Manufacture of machinery and equipment n.e.c., except Manufacture of weapons and ammunition
30+31+32+33	Manufacture of office machinery and computers; Manufacture of electrical machinery and apparatus n.e.c.; Manufacture of radio, television and communication equipment and apparatus; Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
36+37+23.3+24.61+29.6	Manufacture of furniture; manufacturing n.e.c.; Recycling; Processing of nuclear fuel; Manufacture of explosives; Manufacture of weapons and ammunition
40+41	Electricity, gas and water supply
45	Construction
50+51+52	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel; Wholesale trade and commission trade, except of motor vehicles and motorcycles; Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
55	Hotels and restaurants
60+61+62+63	Transport
64	Communication
65+67	Financial intermediation; activities auxiliary to financial intermediation

66	Insurance
70	Real estate activities
72	Computer and related activities
73	Research and development
71+74	Renting of machinery and equipment without operator and of personal and household goods; other business activities
75+91	Public administration and defence; compulsory social security; activities of membership organizations n.e.c.
80	Education
85	Health and social
90	Sewage and refuse disposal, sanitation and similar activities
92	Recreational, cultural and sporting activities
93	Other service activities

Appendix B. Disaggregation of Use Tables and Valuation Matrices

In this Appendix, we give a formal description of the procedure which we use to disaggregate a given detailed use table at purchasers' prices (denoted below by $\mathbf{U}_p$) into five unknown components, that is, the use table in basic prices of domestic production ($\mathbf{U}_1$) and of imports ($\mathbf{U}_2$), the matrices of trade margins ($\mathbf{U}_3$), transport margins ($\mathbf{U}_4$), and net taxes on products ($\mathbf{U}_5$). All the above five tables include both intermediate use and final demand and contain, say, M rows (products) and N columns (activities) each (in this paper, we have M=95 and N=127). We use the official data on use tables and valuation matrices for each of the above five tables in a higher aggregated level. Formally, this means that there are given versions $\mathbf{W}_1$--$\mathbf{W}_5$ of the above tables $\mathbf{U}_1$-- $\mathbf{U}_5$ aggregated up to m rows and n columns where m<M and n< N (in our situation, m=24 and n=34). The aggregated use matrix $\mathbf{W}_p$ at purchasers' prices is therefore equal to the matrix sum $\mathbf{W}_1+\ldots+\mathbf{W}_5$. We also assume that the row totals for all matrices $\mathbf{U}_1$--$\mathbf{U}_5$ are also known, that is, we have given five M-dimensional vectors $\mathbf{q}_1$--$\mathbf{q}_5$ such that $\mathbf{q}_i = \mathbf{U}_i \mathbf{1}_N$ for each i =1…5 (where $\mathbf{1}_N$ denotes the N-dimensional vector of units) and $\mathbf{q}_1+\ldots+\mathbf{q}_5 = \mathbf{q}_p$, where the vector $\mathbf{q}_p$ of total use at purchasers' prices is equal to $\mathbf{U}_p \mathbf{1}_N$.

To provide the disaggregation, we adopt the GRAS algorithm by [Junius & Oosterhaven, 2003] in its most general version given in [Lenzen et al., 2009, subsection 3.1]. Let x_{ijk} denotes the (j,k)-th element of the matrix $\mathbf{U}_i$, where i =1…5, j=1..M and k=1..N. Then each variable x_{ijk} constrained by three equations of the following origins. First, the row sum $\sum_{k=1}^{N} x_{i,j,k}^{0}$ is equal to the j=th element q_{ij} of the vector $\mathbf{q}_i$. Second, x_{ijk} belongs to a collection of cells of $\mathbf{U}_i$ which is aggregated to some cell of the matrix $\mathbf{W}_i$, which gives another linear equation on the elements of this collection (i.e., the sum of the values of all cells in the collections is equal to the value of the corresponding cell of the matrix $\mathbf{W}_i$). Third, the 5-element sum $\sum_{i=1}^{5} x_{i,j,k}$ is equal to u_{jk}, the (j,k)-th element of the matrix $\mathbf{U}_p$.

Consider a vectorization of the above equations, that is, a system **G x** =**a**, where **x** is a vector of dimension p=5MN with the components x_{ijk}, **G** is a p×q matrix and **a** is a vector of dimension q, where q = 5M+5mn+MN is the number of the equations of the system. We use an (unbalanced) benchmark tables $\mathbf{U}_1^0$--$\mathbf{U}_5^0$ to obtain a benchmark vector $\mathbf{x}^0$ by the same way as the vector **x**. Then we use $\mathbf{x}^0$ as the initial value for the generalized RAS iterative procedure as described in [Lenzen et al., 2009, subsection 3.1]. This means that we minimize the function

$$f(\mathbf{x}, \mathbf{x}^0) = \sum_{i,j,k} |x_{i,j,k}| \ln \frac{x_{i,j,k}}{e x_{i,j,k}^0}$$

subject to the equations **G x** =**a** and sgn $x_{i,j,k}$ = sgn $x_{i,j,k}^0$ for all i,j,k, where the sum is taking over all triples (i,j,k) such that $x_{i,j,k}^0$ is nonzero. The condition on signs means that the zero and negative values of $x_{i,j,k}^0$ stay zero and nonpositive, respectively, as the values of $x_{i,j,k}$

The solution of the above minimization problem is discussed in [Lenzen et al., 2009, section 3]. Namely, by a version of [Junius & Oosterhaven, 2003, Theorem 1], there are positive numbers $r_1,\ldots,r_p$ such that $x_{i,j,k} = r_a\ r_b\ r_c\ \ x_{i,j,k}^0$ if $x_{i,j,k}^0$ is positive and $x_{i,j,k} = x_{i,j,k}^0 / (r_a\ r_b\ r_c\ )$ if $x_{i,j,k}^0$ is negative, where *a,b,c* are the numbers of the three constraints on $x_{i,j,k}^0$. These numbers $r_1,\ldots, r_p$ are the exponents of the Lagrange multipliers; one can find them by solving the corresponding Largange system. Following [Lenzen et al., 2009, subsection 3.2], the iterative algorithm based on Bregman's balancing method is a generalization of the RAS algorithm with a recurrent formula for the multipliers $r_1,\ldots, r_p$, see the formula (8) in *Op. Cit.*

Note that the three multipliers r_a, r_b, r_c for each unknown $x_{i,j,k}$ correspond to the three types of constrains listed above. Here r_a is a standard substitution factor of the RAS procedure. It is traditionally interpreted as a measure of effect of the substitution of a given factor by other factors in the corresponding table $\mathbf{U}_i$. Analogously, one can interpret the multipliers r_b as `aggregation factors', that reflects changes in economy which preserve the proportions of aggregation in each cell of the aggregated table $\mathbf{W}_i$. The factor r_c reflects the demand changes which do not affect to the proportions of the value at basic price, the margins and the taxes in the corresponding value at purchasers' price in the table $\mathbf{U}_p$.

Note that a similar version of RAS algorithm with three multipliers for each item has been applied in [Gilchrist & St. Louis, 1999] to the problem of recovering Canadian regional input-output tables using the state one.

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