Sources of Economic Growth for the period from 2003 to 2014 in Russia: a Structural Decomposition Analysis (SDA)

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Introduction

The last thirty years for the Russian economy have been characterized by a transition from plan to market. During this time, the Russian economy has experienced periods of recession and rapid recovery, the potential of which approached exhaustion at the end of the first decade of the 21st century. Three crises were superimposed on these trends: 1998, 2008 and 2014, accompanied by a decline in production, followed by a rapid (after the crises of 1998 and 2008) or a long (after the crisis of 2014) recovery of economic growth. Despite the fact that, in general, over the period covered, the volume of production in Russia increased slightly[1], large-scale changes in its structure occurred [Baranov, Bessonov, 2018]. Among such changes, there are large structural changes in the industries, characterized by changes over time of the structure and production volumes of various domestic goods. In the intercrisis decade (1998–2008) and the period from 2009–2014 production of manufacturing industries grew at a fast pace, while production of extractive industries, showed a smoother dynamics. In the period of recession (2008–2009) however, production of extractive industries fell slightly, while the dynamic of the manufacturing industries, showed a more noticeable decline in production[2]. In addition, in the intercrisis decade (1998–2008) and the period from 2009–2014 there was a sharp growth in the services, whereas the mining and manufacturing industries saw a slower growth; we also saw a growth in production and exports, but a sharper growth in products imported[3].

The presented dynamics of indicators can be considered as quite an understandable phenomenon. In Russia, in the epoch of a planned economy, the service sector was not developed, in the process of becoming a market, it only "made up for lost time". With regard to the dynamics of the manufacturing industry, in a transition economy, to which the Russian economy was in the period under review, "products of the manufacturing sector were characterized by greater mobility compared to the more stable dynamics of raw material extraction.[4]" The third phenomenon is also a characteristic of developing transitional economies, and largely explained by an increase in

[1] During the period from 1990 (the last year before the start of an intense transformational recession) to 2014, Russian GDP grew by only 19%, i.e. its average annual rate was only 0.7% [Baranov, Bessonov, 2018].
[2] For more details, see the Industrial Production Intensity Index section "Dynamics of Production and Foreign Trade" "Center of Development Institute" of the HSE. https://dcenter.hse.ru/dynamics, [Bessonov, 2009].
[3] It means the period from 2000 to 2012. See Gross Domestic Product by expenditure Annual data In Constant prices. http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/#
[4] For more details, see [Bessonov, 2005, p.205].

welfare. However, such an explanation does not answer a number of important questions. What acted as a growth driver in the manufacturing industry and services at the recovery stage, whose annual rates averaged about 7.2% per year[5], and its decay[6], when the growth rates declined on average to 1% per year? How did the transition to the market and the liberalization of foreign trade affect the structure of production and the rate of economic growth?

These questions are relevant. Today, the Russian economy is a small open economy, that has almost completed the transition to a market for which a development strategy, defined in terms of trade policy, has a significant impact on growth and production structure. As noted above, from 1992 to 2014, a foreign trade liberalization policy was in force, characterized by a relatively free trade regime, with small quantitative controls and price measures. During this period, imports began to have a significant impact on domestic production and consumption, which was largely supported by macroeconomic policies, along with trade liberalization and welfare. From 2014, there was a transition to the policy of import substitution in a number of key sectors of the economy, accompanied by a change in the policy regime. The change of trading strategy and policy regime against the backdrop of the fading of transitional processes requires a deep understanding of the historical results of the previous development strategy. This will lay a reliable basis for assessing the possible economic consequences of an alternative import substitution policy (within the framework of scenario calculations).

The purpose of this paper is to evaluate the effect of the transition to the market,[7] and the liberalization of foreign trade on the structure of production in the periods from 2003 to 2014 (growth phase), and 2014-2015 (phase of decline).

The available data does not allow us to separate both of these effects; therefore, their joint influence is considered, reflected in changes in the structure of domestic final demand, international trade and the use of production technologies. To assess the contribution of indicators describing domestic final demand, international trade, production technologies, as well as import substitution with domestic goods and services to changes in output levels and structure, we use the input-output structural decomposition method (Input-Output Structural Decomposition) Analysis, IO SDA). Thus, we examine the level and structure of production from the position of changing

[5] "In the intercrisis decade, GDP increased by exactly 2 times (an average of 7.2% per year), and consumer prices rose 4.3 times (by 15.7% on average per year). The high rates of recovery were largely due to the great depth of the previous transformational decline." [Bessonov, Baranov, 2018].

[6] This refers to the period since 2008. For more details, see [Bessonov, Baranov, 2018].

[7] Among the effects of transition to the market, there are, for example, the emergence of incentives for resource saving at the micro level, the development of more efficient technologies and methods of production organization, etc. [For more details, see Bessonov, 2005].

the structure of output necessary to meet the changing needs of economic agents and the use of technology (i.e., from the demand side)[8].

The presented study is a continuation of the work of 2016[9]. In previous works on the basis of SDA, the impact of changes in intermediate demand and domestic final demand and exports on the increase or decrease in the levels of domestic goods and services output and imports in general in the Russian economy, and in the context of 34 industries between 2003 and 2010, was estimated. The base for the analysis, was the symmetric input-output tables (industry-industry) for the Russian Federation, from the World Input-Output Database (WIOD) project for 2003 and 2010. In the approach used in 2016, the effect of import substitution with domestic products we can see by comparing the increase (decrease) in imports with the increase (decrease) in domestic products as a whole in final demand, and its elements.

The principal difference of the current study from our previous work, is that in this study we intend to single out 1) technological changes and 2) import substitution with domestic products for both intermediate and final products (see part 1). In addition, for the decomposition, we use symmetric input-output tables, based on the official data of Rosstat. Symmetric input-output tables (product-product) for 2012-2015 we designed using officially published supply and use tables for domestic and imported goods and services for 2011-2015, in classification, harmonized with international analogues[10]. In addition, we also constructed symmetric input-output tables (product-product) for 2003, based on the available information.

The availability of a series of input-output tables (product-product) for 2003, and the period from 2011-2015, allowed to cover part of the transformational recovery (2003-2011) and the beginning of the period of attenuation (up to 2015 inclusive).

This paper consists of an introduction and three parts. The first part is devoted to the description of the method of the structural decomposition analysis, the identification and justification of the determining factors that influence the change in the volume of domestic output and import. The second part describes the preparation of data for the structural decomposition analysis approach. Particular attention is paid to the description of the algorithm for constructing symmetrical input-output tables, the preparation of deflators for 58 types of domestic products and

[8] There are two opposing views on how economic growth takes place: the neoclassical (supply side approach) and structural (demand side approach). Discussion of the choice of approach is beyond the scope of the report. We mention only in this connection, only recently published work [Baranov, Bessonov, 2018]. One of its main conclusions is that when considering the production function for the Russian economy in the framework of an alternative neoclassical approach, the dynamics of output at the stages of recession and recovery, was largely determined by the influence, not of factors of production, but total factor productivity, TFP. At the same time for the Russian case in this indicator, the contribution of measurement errors is too high.

[9] See [Baranov, Elsakova, Korneva, Staritsyna, 2016].

[10] The problem of comparability of domestic and international statistics has repeatedly been raised in the domestic literature, see for example, [Baranov, Kim, Piontkovsky, Staritsyna, 2014].

the procedure for recalculating input-output tables to constant prices. The third part presents an analysis of the results of the calculations.

I Structural decomposition analysis

The input-output structural decomposition analysis, IO SDA, originates from the work of B. Leontief, 1941 and Chenery et al., 1962. This method provides an analysis of changes in macroeconomic proportions, by comparing static changes in key indicators of input-output tables[11]. The intuitive basic method of structural decomposition is the observation that consumption growth stimulates production growth in the economy, i.e. goods and services are produced because they are in demand. Intermediate demand is generated by other domestic producers. Final demand is measured by domestic final consumption and gross capital formation, which constitute domestic demand, as well as sales abroad (external demand). In an open economy, domestic producers compete with foreign producers for the domestic market of intermediate and final goods, as a result of which, the ratio between domestic goods and services and imports changes. However, this method does not involve the identification of factors that affect the demand itself. These factors may include changes in terms of trade, sanctions, changes in technology, etc. Due to the absence of a rigorous theoretical justification, the structural decomposition method is considered to be complementary, rather than competing, in comparison with traditional macro-econometric models. Combined with that and / or other approaches, the structural decomposition method provides a broader understanding of the problem under study[12]. A detailed critical review of this method is presented in [Rose, Casler, 1996].

As part of the decomposition analysis method, H. Chenery proposed explaining economic growth, measured through output growth, in terms of the contribution of changes in technology, final internal and external demand, and substitution of imports with domestically produced goods (or import substitution)[13].

As stated in a widely cited critical review of the structural decomposition method, “change in technology”[14] in structural decomposition is a rather vague concept. It can be represented by: technological changes in a pure form (input of new production methods, for example, robotization of production), effect of scale of production, changes in relative prices for intermediate costs, changes in the ratio between imported intermediate and domestic intermediate goods, etc[15].

[11] See [Rose and Casler, 1996] for more details.
[12] For details, see [Rose, Chen, 1991].
[13] See [Chenery, 1960], Chenery et al., 1962].
[14] See [Rose & Casler, 1996, p.42].
[15] A detailed list of causes (factors) affecting the change in technology is presented in [Miller and Blair, ch.7, 2009, p.303-304].

In general, import substitution is the ratio of changes in the value of imports, to changes in the value of imports and domestic products, calculated separately for intermediate and final goods and services. In our opinion, entering the decomposition index for import substitution with domestic goods and services (import substitution), will provide an idea of the distribution channels for imports in the Russian economy, and assess the extent of its impact on both domestic production and consumption.

An important feature of the structural decomposition method is the selection of sub-periods for analysis. In order to correctly interpret the results of the analysis, it is desirable to single out periods that (with an acceptable degree of conditionality) were affected by the same factors.

II Constructing symmetrical input-output tables of domestic products and imports

To carry out structural analysis, it is necessary to construct symmetric matrices (I and II quadrants of the input-output table for domestic products and imports (for 2003, 2011, 2013 and 2015). Rosstat has published only symmetrical "product-product" tables for 126 products of economic activity. Since a consistent series of uniform symmetric tables is required here, it was decided to construct symmetrical "product-product" tables in the same nomenclature as the official input-output tables for 2013 and 2015, i.e. for 59 products. These tables were constructed on the basis of official supply and use tables in the assumption of "industry technology", i.e. according to model B in terminology [EUROSTAT, 2008, chapter 11]. In this model, the symmetric intermediate use matrix is calculated as

$$S = U \operatorname{diag}(\mathbf{g})^{-1} V,$$

where U is the intermediate use matrix (that is, the first quadrant of the use table in basic prices), V is the transposed resource matrix (make matrix), **g** is the release vector by industries. According to this formula, symmetric matrices for domestic products and total (for domestic and imported together), were constructed separately. The matrix for imported products was calculated as the difference between of the two. A close model when constructing the official symmetrical table for 2011 was adopted by Rosstat (which also uses additional information). Unfortunately, there is no instrumental description of the model and algorithm used in the Rosstat information. Our approach can be considered a simplification of the method used by Rosstat.

To estimate the error of this simplification, a comparison was made of the 2011 tables constructed using the described method with aggregated to the same level of disaggregation (59 products) of the official symmetric tables of the Rosstat. For most products, the discrepancies in the totals of the columns of the constructed and aggregated tables are no more than 2–3%: these discrepancies can be explained by differences in the detail of the initial supply and use tables. However, the

differences in the six categories are more significant. This is "Fishing (05)" (the deviation of the data of the Federal State Statistics Service from the calculations based on Model B, was +29.8%), "Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying (11)" (–11.9%), "Manufacture of coke, refined petroleum products and nuclear fuel (23)" (+11.8%), "Wholesale trade and commission trade, except of motor vehicles and motorcycles (51)" (–10.3%), "Real estate activities (70)" (–16.3%), "Renting of machinery and equipment without operator and of personal and household goods (71)" (–56.9%). In general, the error can be considered acceptable for structural analysis.

Recalculation of symmetrical input-output tables at constant prices

Recalculating the input-output tables at constant prices is one of the difficult problems of intersectoral analysis (note that the official statistical agencies of the overwhelming number of countries prefer not to deal with this problem at all). Price statistics for domestic production is carried out on a monthly basis, and it is not always possible to correctly convert monthly price statistics, to average annual figures (that is, deflators for recalculating rows of symmetrical input-output tables from prices of one year to prices of another year). The average annual prices for goods representatives, are far from always sufficient, to adequately reflect the content of the aggregated product group in the input-output tables. Producer price indices, relative to the previous month are unsuitable for conversion into average annual price indices for those goods and services the monthly structure of output in the detailed classification of which varies greatly during the year due to seasonal and other factors. For example, in 2012 compared to 2011, the average annual producer price index for agricultural products, calculated by averaging the monthly data using the trapezoid method, was 96.4%, while the implicit deflator for this type of activity, based on SNA data, was 109%.

In this connection, we used implicit deflators calculated on the basis of more correct SNA data, to recalculate symmetric input-output tables into constant prices.

The constructed symmetrical input-output tables for the Russian Federation are presented broken down into symmetric input-output tables of domestic products and symmetric input-output tables of imports. 2011 was chosen as the benchmark year because it was used by Rosstat to calculate the SNA indicators for the Russian Federation. To recalculate the data of the symmetric product-product tables of domestic products at constant prices for domestic production, implicit deflators were used that were built by the authors, according to the SNA (the rate of change in output by type of economic activity at current prices is divided into volume indices of output by type of economic activity in percent to 2011). To recalculate the symmetric "product-product" imports in terms of goods, we used deflators for large commodity groups (indexes of average prices for the commodity structure of imports of the Russian Federation for 2003, 2011-2015),

reduced to the base 2011. In this case, the indices for the relevant product groups were used as deflators by type of economic activity, based on the similarity of the position content. For example, the index for the commodity group "Mineral Products" was considered equal to the deflator by type of economic activity "Manufacture of coke, refined petroleum products and nuclear fuel". Price statistics for the import of services are not available, therefore implicit deflators for services, constructed by the authors according to the SNA and adjusted for exchange differences, were taken as deflators of service imports.

To describe the decomposition the following notations are used:

s denotes the vector of units;

E is the column vector of exports (without reexport);

M is the column vector of imports;

X is the column vector of domestic production;

A is the matrix of technological coefficients, $A = A^D + A^M$, where

A^D is (direct inputs coefficients) of domestic products,

A^M is the matrix of technological coefficients of imported products;

Id is the identity matrix;

L^D – is the Leontief inversion of the matrix of technological coefficients of domestic production: $L^D = (Id - A^D)^{-1}$.

The subscripts 0 and 1 are the first and last years of the period under review;

the changes are denoted by Δ, e.g.,

$\Delta X = X_1 - X_0$ is the output change vector.

We use also superscripts D(d) and M(m) for domestic production.

We use the sing C for consumer's demand with the additional superscripts d (for state demand) and h (for household demand). We use also the sign I for the column vector of investment demand, which is the sum of the vector of change in inventories (denoted by the additional superscript *s*) and the fixed capital formation and net value growth (denoted by the additional superscript *gfcf*). For example, $I^{gfcf} = I^{dgfcf} + I^{mgfcf}$ is the decomposition of the latter component of the investment demand into the domestic and imported parts.

We use the formulae

$$\mathrm{X} = (Id - A^D)^{-1}(\mathrm{C^d} + \mathrm{I^d} + \mathrm{E})$$

Then one obtains the following decomposition for the output change:

$\Delta X = \Delta X_1 + \Delta X_2 + \Delta \mathrm{X}_3 + \Delta X_4 + \Delta X_5 + \Delta X_6 + \Delta \mathrm{X}_7 + \Delta X_8 + \Delta X_9 + \Delta \mathrm{X}_{10}$,

where

ΔX_1 - *technological change,*

ΔX_2 – *substitution of imported intermediate goods by domestic production,*

ΔX_3 – *external demand expansion,*

ΔX_4 – *investment demand expansion,*

ΔX_5 – *substitution of imports of investment goods by domestic production*

ΔX_6 – *changes in inventories expansion, including the substitution of imports by domestic production in inventories)*

ΔX_7 – *household demand expansion*

ΔX_8 – *substitution of imports of consumer goods by domestic production for households and NPISHs*

ΔX_9 – *general government demand expansion*

ΔX_{10} – *substitution of imports of goods by domestic production for general government*

III The results of decomposition analysis

Sources of output growth for 2011-2014 **Table 1**

	growth rate	External demand expansion	Domestic demand expansion (Households+NPISHs)	General government demand expansion (Collective+ Individual)	Investment demand expansion Gross fixed capital formation + acquisition less disposals of	Changes in inventories expansion	Substitution of imports of intermediate goods by domestic production	substitution of imports of final goods by domestic production (Households+NPISHs)	substitution of imports of final goods by domestic production (government)	substitution of imports of final goods by domestic production (investment demand)	Technological change
Production of manufacturing industries	5.2	53.0	63.0	0	-57	38.1	0.0	7.0	0.0	1.0	-7.0
Services	8.7	0.7	76.1	7.5	-9.3	10.9	1.2	1.7	0	0.2	11.2
products of the extractive industries	2.8	-12.1	84.4	0.6	-113.6	13.6	19.6	1.7	0.1	0.5	105.1
agriculture, hunting and related service activities	3.8	96.5	107.6	5.2	-74.3	-14.0	20.8	19.0	0.1	5.4	-66.2
total	6.8	17.6	73.2	5.2	-27.8	18.5	1.9	3.7	0.0	0.7	7.0

The results of the decomposition analysis are presented in tables 1 and 2.

We found that over the period of 2003-2014, the main driving force of the growth in output, both in the economy as a whole, and in the context of types of products of manufacturing industries and services, was domestic consumer demand. We also noted a gradual increase in the share of services in intermediate consumption (which is quite natural during the transformational period of transition to market relations). This mainly relates to trade, auxiliary and additional transport activities, communications, financial activities and real estate transactions. Finally, over the entire observation period, the resource-saving effect was most clearly manifested by the type of product "Electricity, gas, steam and hot water supply". This is evidenced by the decrease in output for this type of product against the output growth, both in the economy as a whole, and in the context of most goods and services.

At the stage of recovery (2003-2011), the growth rate of domestic output, both in the economy as whole, and manufacturing products in particular, lagged significantly behind the growth rate of imports; there was a substitution of domestic products, in technology, investment and consumption with imports. External demand for products of manufacturing industries also decreased. The prevailing situation was largely promoted by the policy of a strong ruble. The positive aspects include the growing contribution of investment demand for all types of products, and the economy as a whole, as well as increased specialization and deepening of inter-industry interactions for most types of goods and services.

In the period from 2011-2014 the increase in output of the extractive industries was insignificant. For products of section C the increase was 2.8%, for products of sections A and B - 3.8%, i.e. within about 1% on an annualized basis. At the same time, according to data for 2011, the share of products of the extractive industries of sections A and B was 3.8%, of section C - 7.5%.

While the increase in services amounted to 8.7% the output of manufacturing products was 5.2%. At the same time, according to the data for 2011, the share of products of the manufacturing industries from sections D, E, F, was 38.3%, services (G-P) - 50.6%.

Compared with the previous period from 2003 to 2011in the change in the output of manufacturing products, the sections D, E, F (codes 015-045), significantly increased the contribution of exports. The demand in the foreign market to a large extent than in the domestic consumer market, turned out to be products of coke, refined petroleum products and nuclear fuel (division 23), products of basic metals and fabricated metal products (27), products of other transport equipment (35). At the same time, for metals (27) and products of other transport equipment (35) the increase in demand from foreign and domestic consumers, was accompanied by an increase in import substitution in intermediate, consumer and investment goods. Among the major positions, import substitution in intermediate, consumer and investment goods also

occurred in food products, beverages and tobacco, (15) and agriculture, hunting and related service activities (01). In general, for the economy for intermediate and final goods and services, import substitution accounted for 6.4% of the increase in output.

For other types of products, import substitution was extremely insignificant or there was an import promotion. Particularly active replacement of intermediate goods of domestic production by imported counterparts occurred in the construction (45), extraction of crude petroleum and natural gas; service activities incidental (11), chemicals and chemical products chemical substances except explosive substances (24 *), and Computer and related activities (72). The last two of these, are products of a high technological level. Thus, by the time of the active transition to the policy of import substitution, only certain types of products of the manufacturing industries were in demand in the domestic, (of the largest positions are products of 01 and 15 types of economic activities), and in the foreign market (of the largest positions are products of 23 and 27 of types of economic activities). At the same time, on products 01, 15 and 27 there is a decrease in imports.

As for the products of the extractive industries, the main contribution to the change in its output was made by technological changes, by type of product, "Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying". Apparently, there has been a technological shift in this type of product, associated with the provision of drilling and drill boreholes in the Far North. Over the entire observation period, the resource-saving effect was most clearly manifested by the type of product, "Electricity, gas, steam and hot water supply". This is evidenced by the decrease in output for this type of product against the output growth, both in the economy as a whole, and in the context of most goods and services.

At the same time, practically all types of products showed a decrease in investment demand. It is especially significant in the production of extractive raw materials in sections A, B, C. At the same time, the renewal of production, if carried out, was mainly due to the introduction of new equipment, components and advanced materials imported (mainly in manufacturing products and services).

Sources of output growth for 2014-2015 **Table 2**

	growth rate	External demand expansion	Domestic demand expansion (Households+NPISHs)	General government demand expansion (Collective+ Individual)	Investment demand expansion Gross fixed capital formation + acquisition less disposals of	Changes in inventories expansion	Substitution of imports of intermediate goods by domestic production	substitution of imports of final goods by domestic production (Households+NPISHs)	substitution of imports of final goods by domestic production (government)	substitution of imports of final goods by domestic production (investment demand)	Technological change

products of the agriculture, hunting and related service activities	-9.2	-2.9	-139.0	-3.9	7.6	2.2	-1.9	7.9	0.2	0.1	24.0
products of the extractive industries	-18.9	-24.3	-11.8	-1.2	1.6	-13.5	-4.3	0.6	0.0	0.0	-47.3
Production of manufacturing industries	-13.0	-1.2	-46.9	-3.0	3.7	-30.4	5.4	3.2	0.1	0.1	-30.8
Services	-1.8	22.0	-247.9	-27.4	6.9	-67.8	-8.2	5.6	-0.1	0.0	216.9
total	-7.5	-2.3	-69.4	-5.7	3.9	-30.6	1.7	3.2	0.0	0.1	-0.8

The decline in 2015 was most affected by the decline in demand from households and NRISHs, changes in inventories, and demand from the government. The contribution of the remaining elements is not significant. It draws attention to the fact that external demand also made a negative contribution to changes in domestic production and imports, but this contribution was insignificant. This is due to the fact that the deterioration in the terms of trade during this period was accompanied by a significant reduction in contract prices (prices of raw materials – the main Russian export item), while the volume indices of exports declined slightly, i.e. as long as we supplied products in physical terms abroad, before the onset of the crisis, approximately the same amount of exported row materials continued to be delivered in the period from 2014 to 2015. As for the products of manufacturing industries, the fall in external demand against the background of the depreciation of the national currency, is due to a decrease in competitiveness in the external market[16]. For the period from 2014-2015, the authors confined themselves to the presentation of the structural decomposition, of the factors of the dynamics of production and imports as a whole,

[16] According to researchers from the IMF, several factors weakened the competitiveness of products of domestic manufactured products (the services were not considered in the study) exported from 2014 to 2016:
1) The current episode of the fall in commodity prices (primarily oil), coincided with a slowdown in the economic growth of trading partners, the main consumers of Russian non-commodity products. In addition, the low economic growth of trading partners reduced the incentives to introduce new, more complex types of products in the markets of trading partners. This in turn was a significant limitation of the possibility of changing the structure of exports in favor of newer and more complex products.
2) It has been empirically confirmed (based on data from countries, including Russia) that a sudden weakening of the ruble exchange rate against the dollar, as a result of deteriorating terms of trade, creates serious difficulties for the economy and may hamper the redistribution of resources from raw materials to non-commodity traded industries. This is due to the uncertainty of the direction of the future movement of the exchange rate, the irreversible nature of the Dutch disease, the weakness of the banking sector.

without separation by types of goods and services, since the estimates for this period will be refined again.

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