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MACROECONOMIC PROBLEMS

Toolkit for the Input–Output Analysis of the Performance of Russian Economy in 1991–2013

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Abstract—Input–output analysis has been used to study the impact made by microstructure factors such as final demand and the matrix of input–output coefficients on the performance of the total gross output of the Russian Federation in 1990–2013. The contribution of these factors to the economic dynamics during the transformational recession in 1991–1998 and the subsequent restoration growth of 1999–2013 have been numerically estimated.

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The structure of an economy largely reflects the level of the country's development and also determines the possibilities of its further growth [1–4]. Structural studies of the Russian economy are of fundamental importance, especially over the period of its historical transition from the planned Soviet system to the market system. The transition to a market economy was largely due to structural disproportions accumulated over the last decades of the Soviet period. At the same time, the implementation of this transition has brought about new significant structural imbalances, which remain an essential element of the modern Russian economy.

Ideally, an investigation of the structure of the economy should cover changes in all its elements and in all sectors. We believe this requirement can be best satisfied by the input–output approach because the input–output balance is an informational and analytical system reflecting the interaction of all industries, as well as the main market subjects, i.e., the state, households (population), and business. This article analyzes the main structural characteristics of the economic downturn in 1991–1998 and the subsequent economic growth of 1999–2013. These shifts are described in terms of contributions made by the factors of the elements of the final demand, as well as by the input–output coefficients, which allows us to obtain some meaningful insight into the internal structural mechanisms that operated in the studied period. In addition, this is the problem that can be solved using the possibilities offered by an input–output balance.

Solving this problem requires the development of a special toolkit that enables convenient and clear demonstration of changes in the contribution of these inputs (factors) in their dynamics (over the entire described period), which thereby provides a detailed insight into the relative impact of the final demand elements on the economic dynamics in general and the production dynamics in certain types of economic activity that show the change in this impact in time and its current significance for the state of the Russian economy. The same goes for estimating the influence of input–output coefficients, which implies assessing the effectiveness of the economy and the nature of its technological development. It is also important to note that changes in the elements of the final demand, as well as their impact on the total values of gross output (in both individual economic activities and generally on the total gross output) mainly reflect changes in the quantitative proportions while changes in the cost structure of a specific activity reflect qualitative changes. If an industry is capable of producing the same amount or more products over time, using fewer primary resources, this clearly indicates an increase in the effectiveness of this type of activity, which indicates certain qualitative technological developments. Thus, in the presented study, qualitative changes in the economy are mainly related to changes in the input–output coefficients.

To analyze the structural changes in the Russian economy, a toolkit was developed based on a series of input–output balances drawn up by the Institute of Economic Forecasting of the Russian Academy of Sciences for 1990–2013 at constant and current prices. This toolkit includes two interrelated models, i.e., the model of the 1991–1998 recession and 1999–2013, which in turn includes a period of recovery growth in 1999–2008, as well as the subsequent years of unsustainable development.

The available information base was brought to a form suitable for developing a tool for factor analysis. First of all, we ran the classical Leontief model for input–output balances (IOB) at constant prices (for each year). Thus, balances were drawn up for each year by calculations depending on the values of the elements of the used GDP and input–output coefficients. In turn, the calculated balances in current prices were drawn up as the product of IOB in constant prices based on the price vector.

Since it is important to determine how changes in key variables that determine demand and technological potential have affected the development of industries and the economy as a whole, and the resulting models were adjusted to provide exogenous specifications, not of the elements of the final demand and input–output coefficients, but their increments. Thus, in the static model of the input–output balance, the input coefficient matrix (matrix A), as well as the elements of the used GDP that are exogenous.

In the considered toolkit, the input matrix is formed as follows:

$$A = A^{t\_base} + \Delta A, \quad (1)$$

where A^{t_base} is the input coefficient matrix of the base year and $\Delta A = A - A^{t\_base}$.

Increments in the input–output coefficients ΔA act as exogenous variables in our analytical toolkit. Here, for the relative consideration of increments in exogenous variables and the corresponding increments in the resulting indicators, when analyzing the recession period, it is natural to use 1990 as a comparator, while the evident comparator for 1999–2013 is 1998. Thus, different years are used as comparators when analyzing different periods.

A similar method is used to obtain the values of the household consumption and other elements of the final demand, i.e.,

$$Pce = Pce^{t\_base} + \Delta Pce, \quad (2)$$

where Pce is the household consumption, and Pce^{t_base} is the household consumption of the base year, and $\Delta Pce = Pce - Pce^{t\_base}$.

In order to analyze the effect of price changes and price proportions, the difference between the deflator of the current year and the corresponding deflator of the base year was also calculated for each sectoral element of the price vector,

It should be noted that, over the entire considered period (for each year) ΔA, ΔPce, and other Δ-variables were calculated as the difference between the current year indicator and the respective element of the base year.

In the resulting computational model structure, Δ variables are actually exogenous. In this case, the control of this structure consists of the possibility of specifying exogenous variables such that the Δ variables assume either zero or real value.

The practical implementation of the model provides for appropriate control values so that when the Δ-control variable is assigned a zero value, the Δ-exogenous variable of the first or second quadrant coupled with it is also equal to zero. If the Δ-control variable is assigned a value of unity, the value of the corresponding Δ-exogenous variable of the input–output balance is equal to its real value in the analyzed period. In this case, over the entire time period, the zero or unity value can be assigned either to a specific sectoral Δ-control variable or to the entire column or to part of the matrix of the first or second quadrant of the IOB. Theoretically, it is possible to use a wide variety of combinations for the simultaneous assignment of zero and unity values to a particular set of Δ-control variables. The only issue is a meaningful interpretation of the initial statement of the problem and the obtained results.

This toolkit enables the researcher to study a wide range of structural changes in the Russian economy over the post-Soviet period. For example, when analyzing the 1991–1998 recession, assigning zero values to all Δ-control variables of the elements in the second quadrant (actually, this implies that all elements of the GDP used throughout the whole period remain at the level of 1990) if the real values of the matrix of input–output coefficients are preserved (in this case, the corresponding Δ-control values are equal to 1), this means that it is possible to evaluate the contribution of technological changes in the economy to the economic dynamics and structure of production. Moreover, during comparison with actual accounting statistics, taking into consideration the dynamics in sectoral outputs obtained by the above-described calculation method provides an insight into the consequences of technological changes in the economy as a whole for specific sectoral outputs.

Certainly, the quality of these measurements is definitively determined by the quality of the data presented in the input–output tables (we used the input–output balances of the Institute of Economic Forecasting). Thus, one of the possible applications of the described toolkit can be to verify the correctness of the employed IOBs both in terms of possible discrepancies and with regard to the general validity of their general representation of patterns of structural changes in the Russian economy.

The consideration and substantiation of the calculation results and meaningful statements of the problem should necessarily be preceded by a general description of the dynamics in structural changes in the Russian economy over 1990–2013. The scale of balances calculated by the staff members at the Institute of Economic Forecasting that we used in our analysis was 44 × 44 economic activities. At the same time, for greater clarity, we present the results of calculations in the structure of 14 consolidated activities

Table 1. Performance of outputs in consolidated sectors of the economy in constant prices, % (1990 = 100%)

Economy sector	1998	2013
Agriculture and forestry, hunting, and fishing	57	94
Crude-oil production	68	105
Extraction of other minerals	59	94
Production of petroleum products	58	98
Chemical industry	39	100
Metallurgical production	59	105
Manufacture of machinery and equipment	30	73
Other manufacturing activities	37	71
Electric-power generation	71	75
Construction	30	89
Wholesale and retail trade	74	194
Transportation and storage	51	92
Communications and data transmission	71	485
Other services	59	111
Total	53	103

Source: hereinafter in tables and figures are author's calculations.

Table 2. Structure of gross output in 1990–2013, %

Economy sector	1990	1998	2008	2013
Agriculture and forestry, hunting, and fishing	4.7	5.0	4.1	4.3
Crude-oil production	4.3	5.5	4.3	4.4
Extraction of other minerals	3.0	3.3	2.5	2.7
Production of petroleum products	5.2	5.7	4.7	4.9
Chemical industry	2.7	2.0	2.3	2.6
Metallurgical production	4.4	4.9	4.8	4.5
Manufacture of machinery and equipment	7.5	4.3	6.0	5.3
Other manufacturing activities	12.2	8.6	9.0	8.4
Electric-power generation	6.8	9.1	5.3	5.0
Construction	7.8	4.5	7.5	6.7
Wholesale and retail trade	8.5	11.9	15.3	16.1
Transportation and storage	8.3	7.9	7.3	7.3
Communications and data transmission	0.4	0.5	1.6	1.7
Other services	24.1	26.8	25.3	26.0
Total	100.0	100.0	100.0	100.0

obtained by aggregating the initial 44 (see Tables 1 and 2 for a list of consolidated activities).

Over the studied time period, when considering the performance of the total gross output in constant prices of 2010, there are two identifiable qualitatively different intervals, i.e., the period of decline (1991–1998), and the period of recovery growth (1999–2013), which includes the crisis recession in 2009 (Fig. 1, [5] author's calculation).

Conceptually, the period of 2009–2016 should be considered separately as a special period of unsustainable development. At the same time, this is hindered by information constraints as input–output balances are only available up to 2013. Taking this into consideration and in view of the fact that, after 2009, growth in the Russian economy had resumed and, in our calculations, we are mainly going to analyze cumulative changes, it appears acceptable to combine the 1999–2008 period with the 2010–2013 period.

We consider it important to determine the impact of various elements of the final demand and technological changes on the performance of the economy and structural shifts for each of these time intervals. Out of 14 consolidated economic activities, we can

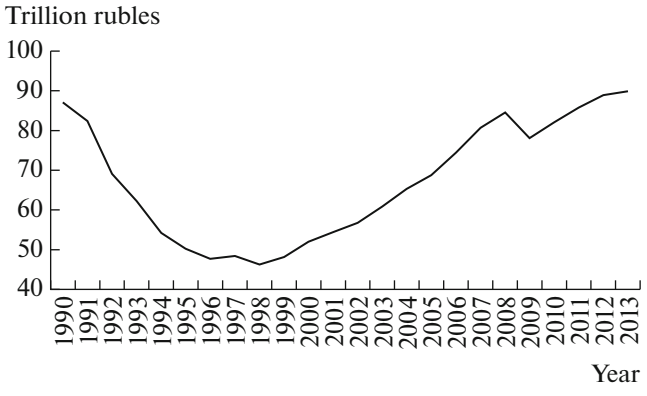

Fig. 1. Performance of the total gross output in constant prices of 2010.

identify those where output volumes (in constant prices) attained or exceeded the 1990 level and those for which the outputs are only approaching this level. The first group only includes six consolidated activities, i.e., oil production, the chemical industry, metallurgy, wholesale and retail trade, communications and data transmission, and other services. The first three are traditional items of Russian exports.

The other three groups of economic activities, the gross output of which exceeded the level of 1990, reflect the changed nature of the domestic economy. Under market conditions, the share of wholesale and retail trade increased significantly from 8.5% in 1990 to 16.1% in 2013 (see Table 2). Interestingly, this trend was preserved even during economic recessions. For example, in 1998 the gross output of trade was 74% of the 1990 level, but its share in the total gross output rose to 11.9%. The total worth of the gross output of trade in comparable prices almost doubled over the entire considered period. The gross output of the service industry in constant prices in 2013 exceeded the value of the same indicator in 1990 by more than 11%, while the overwhelming part of this growth was due to market services. The significant increase in the output and in the share in the total output of activity in the category of communications and data transmission is due to the development of the internet and cellular communications, which are currently among the most dynamic business areas.

Some of the consolidated economic activities, such as the machinery industry, electric power industry, construction, other manufacturing activities, and even agriculture (as of 2013) had not reached the Soviet level of outputs.

From the viewpoint of structural changes in the Russian economy, it is important to note that the ongoing increase in trade is nevertheless accompanied by the resumed reduction in the share of manufacturing industries, including machinery industry observed in recent years. At the same time, the share of the raw material sector in the economy remains almost unchanged with regard to the total output.

Before proceeding to specific calculations, the correctness of the model operation should be verified. To do this, it is sufficient to perform calculations for all (zero and unity) values of Δ-control variables and to compare the results with the actual performance of the outputs (Fig. 2).

Our calculations show that, as should be the case with the correct operation of the model, in the first case (Fig. 2a), the calculated output remained unchanged at the 1990 level and, in the second case (Fig. 2b), it completely coincided with the actual values. Since this toolkit has proved correct, it seems feasible to use it for the most general calculations that demonstrate the main results of interindustry interactions, which lead to changes in the structure of the Russian economy along the trajectory of the 1991–1998 recession. Since our model includes two groups of the main exogenous variables, elements of the final demand, and the matrix of input–output coefficients, we consider the cumulative effect of each complete set of these exogenous variables on the performance and structure of outputs.

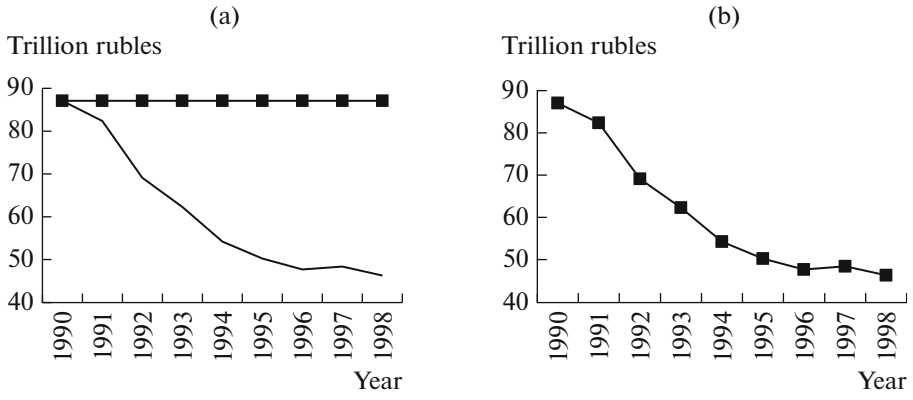

Fig. 2. Total output: — reported values, –■– calculated values.

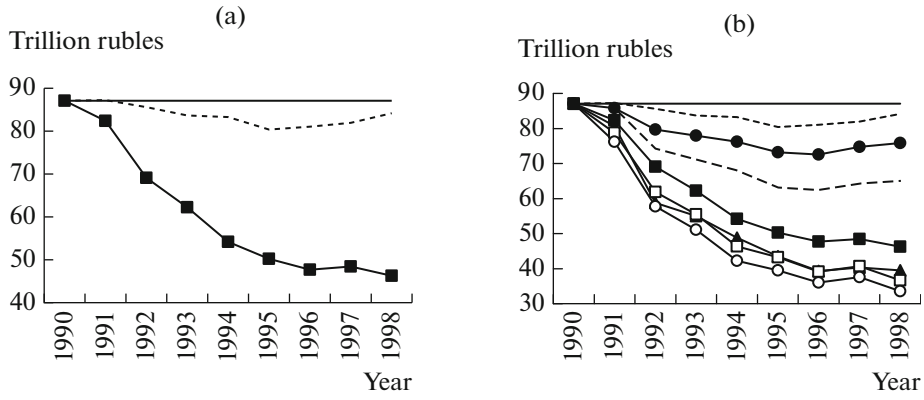

Fig. 3. Total gross output: — initial value of 1990, ––– impact of the input–output coefficients, –●– household consumption, **----** public consumption; –□– stock gain, –○– exports; –■– imports (actual performance of the GDP); –▲– fixed capital formation.

First, we study the impact of input–output coefficients. Obviously, in order to assess the cumulative effect of the change in the input–output coefficients on the Russian economy in 1991–1998, it is sufficient to leave the elements of the final demand unchanged (i.e., assume zero Δ-control values of the final demand) and to make the change in the input–output coefficients in the model consistent with the real developments over the considered period, (i.e., to set Δ-control values of the input–output coefficients equal to 1). For the entire economy, i.e., with regard to the total gross output, the result of the change in the input–output coefficients compared to the actual output values and the 1990 level of the output values is shown in Fig. 3 (author's calculations).

It can be said that the cumulative effect of changes in input–output coefficients did not lead to a significant change in the total output compared to the 1990 values. However, this result can only be attributed to the combination of very different and significant changes that occur in individual sectors.[1] Nevertheless, in general, technological changes in 1991–1998 are expressed in a decreased demand for output, which actually means a reduction in the need for initial primary inputs for the production of final goods. In 1995, cost savings that result from technological changes increased to about 8% of the total output of 1990 and, in 1998, dropped to 3% of the total gross output of 1990.

Thus, the results of these calculations may be used to disaggregate the production decline into the component connected with technological changes and the component due to the changes in the final demand. Accordingly, it is possible to estimate the contribution of each of these aggregate inputs to the overall production decline of 1991–1998.

[1] Analysis of the impact of technological changes in the Russian economy on the performance of sectoral outputs is a subject of a separate study.

Then, the proposed toolkit is used to estimate the contribution made to the economic recession of 1991–1998 by various components of the final demand in order to have more complete and structured insight into the impact of key macrostructural factors on economic dynamics. To do this, by sequentially changing the Δ-control values of the final demand from 0 to 1, we initiate calculations that take into account the impact on output dynamics (in addition to the input coefficients) had by household consumption, public consumption, fixed capital formation, stock gain, and exports and imports. In each subsequent calculation, the total impact of the inputs involved in the previous calculations and the input used to supplement the current calculations are taken into account (Fig. 3, author's calculations). The difference in the results of two consecutive sequential calculations actually reflects the contribution of the last input involved in these calculations to the performance of the aggregate output.

Numerical results are presented in Tables 3–5 in terms of both changes in the output and contributions of input to the economic dynamics.

It should be recalled that Δ-variables employed in the model are represented by the difference between the indicators of the current year and the base year in this series of calculations, i.e., 1990. This implies that the results presented in both the graphs and the tables reflect the changes that accumulated over the period rather than changes that occurred in that particular year. We believe that the accumulated results are of the greatest interest for analysis.

At the same time, whenever necessary, the model design can be modified for calculations on an annual basis; this would only require redefining the control Δ-variables.

Among the results shown in Tables 4 and 5, the balance column, which presents estimates for the entire period of 1991–1998, is of the greatest interest. At the

Table 3. Impact of macrostructural factors on output decline, billion rubles

Indicator	1991	1992	1993	1994	1995	1996	1997	1998
Decrease in output relative to 1990	4679.9	17957.4	24785.6	32840.9	36797.9	39380.1	38640.3	40772.6
Including due to:								
change in the input coefficients	−199.8	1479.7	3401.1	3805.1	6684.5	6038.1	5097.1	2912.0
household consumption	1477.5	5869.7	5727.3	7055.7	7179.2	8456.2	7191.7	8258.6
public consumption	−8.7	5444.8	6777.4	8194.4	10043.5	10123.3	10557.2	10886.2
fixed capital formation	5070.1	15467.4	16094.9	19182.8	19673.6	23098.9	23910.8	25484.0
stock gain	1905.8	−3039.6	−438.1	2454.4	248.5	228.8	−409.1	2824.5
exports	2608.5	4054.4	4431.8	4117.7	3714.0	3052.1	3149.4	3090.5
imports	−6173.5	−11319.0	−11208.7	−11969.1	−10745.3	−11617.4	−10856.7	−12683.3

Table 4. Share of factors of final demand and input–output coefficients in decline in the gross output accumulated since 1990, %

Factor	1991	1992	1993	1994	1995	1996	1997	1998
Change in the input coefficients	−4.3	8.2	13.7	11.6	18.2	15.3	13.2	7.1
Household consumption	31.6	32.7	23.1	21.5	19.5	21.5	18.6	20.3
Public consumption	−0.2	30.3	27.3	25.0	27.3	25.7	27.3	26.7
Fixed capital formation	108.3	86.1	64.9	58.4	53.5	58.7	61.9	62.5
Stock gain	40.7	−16.9	−1.8	7.5	0.7	0.6	−1.1	6.9
Exports	55.7	22.6	17.9	12.5	10.1	7.8	8.2	7.6
Imports	−131.9	−63.0	−45.2	−36.4	−29.2	−29.5	−28.1	−31.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

same time, it should be noted that the presented estimates differ substantially from estimates of the contribution of the final demand elements to GDP growth (Tables 6, 7). The matter here is not only that we also separately assessed the impact of the input matrix with regard to the gross outputs, but that, in estimating the contribution of the final demand to the growth in the gross outputs, we used the input–output model and the effects were also intermediated by the unit cost matrix.

As a result, for instance, with regard to the GDP, if the share of the contribution to its growth made by the

Table 5. Contributions of factors of final demand and input–output coefficients to the dynamics in the decline of the gross output, p.p.

Indicator	1991	1992	1993	1994	1995	1996	1997	1998
Decline in the gross output since 1990	−5.4	−20.6	−28.5	−37.7	−42.3	−45.2	−44.4	−46.8
Including due to								
change in the input coefficients	0.2	−1.7	−3.9	−4.4	−7.7	−6.9	−5.9	−3.3
household consumption	−1.7	−6.7	−6.6	−8.1	−8.2	−9.7	−8.3	−9.5
public consumption	0.0	−6.3	−7.8	−9.4	−11.5	−11.6	−12.1	−12.5
fixed capital formation	−5.8	−17.8	−18.5	−22.0	−22.6	−26.5	−27.5	−29.3
stock gain	−2.2	3.5	0.5	−2.8	−0.3	−0.3	0.5	−3.2
exports	−3.0	−4.7	−5.1	−4.7	−4.3	−3.5	−3.6	−3.6
imports	7.1	13.0	12.9	13.7	12.3	13.3	12.5	14.6
Total	−5.4	−20.6	−28.5	−37.7	−42.3	−45.2	−44.4	−46.8

Table 6. Contributions of the factors of the final demand to accumulated decrease in volume of GDP since 1990, %

Factor	1991	1992	1993	1994	1995	1996	1997	1998
Change in the input coefficients	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Household consumption	29.2	27.8	20.8	19.5	19.5	21.3	18.7	19.5
Public consumption	0.1	44.5	41.1	36.4	43.0	40.3	41.4	39.2
Fixed capital formation	96.6	74.7	59.0	52.6	51.2	53.7	56.6	54.9
Stock gain	38.7	–13.3	2.7	11.3	3.5	2.0	0.6	8.1
Exports	53.5	23.0	19.5	14.3	13.0	10.5	11.0	9.4
Imports	–118.1	–56.7	–43.0	–34.2	–30.2	–27.8	–28.3	–31.1
Sum of the shares Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 7. Contributions of the factors of the final demand to the decrease in the GDP, p. p.

Indicator	1991	1992	1993	1994	1995	1996	1997	1998
Decrease in the GDP relative to 1990	–4.7	–18.8	–25.5	–34.0	–37.1	–39.8	–38.9	–42.0
Including due to								
change in the input coefficients	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
household consumption	–1.4	–5.2	–5.3	–6.6	–7.3	–8.5	–7.3	–8.2
public consumption	0.0	–8.4	–10.5	–12.4	–16.0	–16.0	–16.1	–16.5
fixed capital formation	–4.6	–14.1	–15.0	–17.9	–19.0	–21.4	–22.1	–23.1
stock gain	–1.8	2.5	–0.7	–3.9	–1.3	–0.8	–0.2	–3.4
exports	–2.5	–4.3	–5.0	–4.9	–4.8	–4.2	–4.3	–4.0
imports	5.6	10.7	11.0	11.6	11.2	11.1	11.0	13.1
Total	–4.7	–18.8	–25.5	–34.0	–37.1	–39.8	–38.9	–42.0

Source: author's calculations.

fixed capital formation was 54.9%, then the contribution of the total gross output to this growth is estimated as 62.5%. If we take into account that, when estimating contributions to the growth in the output, allowance is also made for the contribution of the input coefficient matrix with a weight of 7.1%, then the difference in the contribution of the conservation will be even greater. Vice versa, the contribution of the public consumption to the GDP growth in our calculations is much greater (39.2%) than the contribution to this growth made by the gross output (26.7%). Obviously, these differences are determined by the significant difference of the material input of the production of investment goods and the material input of public services from the average material input, i.e., the impact of the input coefficient matrix.

For a more detailed (and year by year) comparison of the calculation results, the contributions of a similar set of inputs to the performance of outputs, and the GDP dynamics, we present the values of the contributions made by the factors of the final demand to the GDP dynamics, which are similar in their content to Tables 4 and 5, which demonstrate the contribution of inputs to the performance of the total output (see Table 6).

The change in the time of accumulating contributions from the inputs is also of some interest. For example, the greatest contribution to the decline in the gross output (as well as in GDP) was made by the reduction in fixed capital formation (Fig. 4).

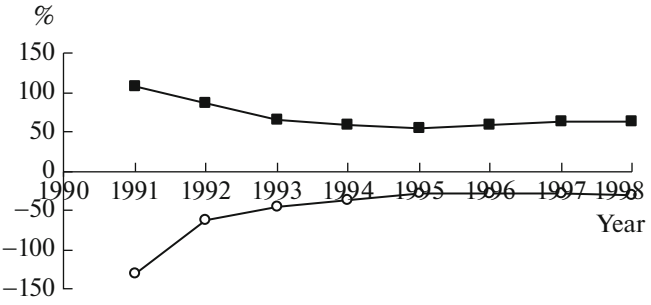

Fig. 4. Dynamics in contributions of saving and imports to volume of gross output decline accumulated since 1990: –○– imports; –■– fixed capital formation.

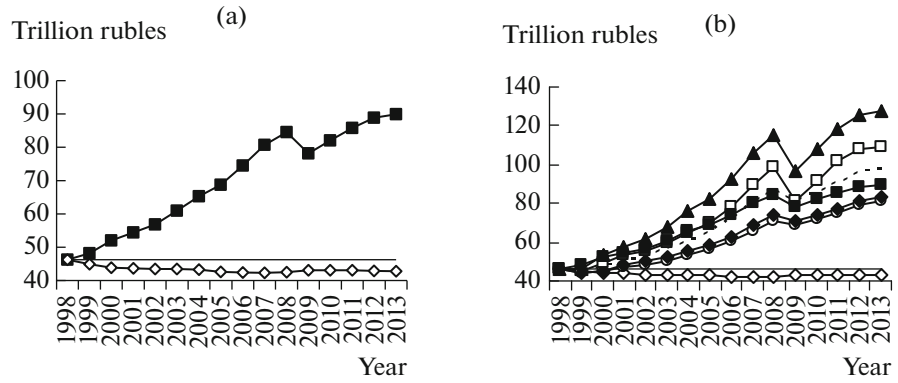

Fig. 5. Consistent impact on gross output of 1998 made by input–output coefficients and elements of the used GDP: — initial value of 1998; –◇– impact of the input coefficients; –○– household consumption; –◆– public consumption, ---- fixed capital formation; –□– stock gain; –▲– exports; –■– imports (actual performance of output).

This impact appeared especially significant at the beginning of the crisis recession. However, this reduction in investment, which adversely affecting the production, was offset somewhat by the sharp decline in import purchases. The decline in imports throughout the crisis recession of 1991–1998 was a significant factor that reduced the scale of production losses. The dynamics of this compensating impact is countercyclical to the dynamics of the impact of investment, which is obviously due to the high initial share of imported equipment in the investment.

Let us further consider the results of similar calculations for the subsequent period of the development of the Russian economy. The calculation technique remains the same as for 1991–1998. The only difference is that 1998 is used as the base year against which the changes and contributions of the inputs are assessed. In addition, in this case, we study the impact on the growth in production (compared with 1998), rather than on its decline.

First, we should estimate the cumulative effect of the change in the input–output coefficients for the economy of the Russian Federation in 1998–2013. To do this, we should leave unchanged the elements of the final demand in the calculation pattern, i.e., zero value should be assigned to Δ-control variables of the final demand, and provide that the change in the input–output coefficients in the model be consistent with the actual figures for the considered period, i.e., Δ-control values of input–output coefficients should be assumed to be equal to 1.

The calculation results show that the use of historical values of input–output coefficients with constant values of the used GDP yields the estimated value of the aggregate final demand below the values of the base year of 1998. The main reason for this is the dynamics of the input coefficients. For the most part, input–output coefficients decrease in the long term, which is primarily due to the development of technologies, the ability to produce more goods using fewer initial, primary resources [3].

Then, similar to the calculations for the recession period, we estimate the contributions of individual elements of the used GDP to the dynamics of the gross output for 1998–2013. As in the previous calculations, we will consistently add the impact made on the contribution of the household consumption, public consumption, fixed assets formation, and exports and imports to the already calculated contribution of input–output coefficients.

It is important to remember that each subsequent calculation takes into account the impact of the inputs involved in the previous calculations, with the addition of the input that is added to the current calculation. Thus, the difference between the results of two successive consecutive calculations similar to the difference calculated for the trajectory of economic recession, reflects the contribution of the last input involved in these calculations to the dynamics of the total output (Tables 8–10, Fig. 5).

Let us dwell in more detail on the results shown in Tables 6–8, where the contributions of the elements of the used GDP and the input coefficients to the dynamics of the change in the gross output of the economy are considered compared to the base year. In other words, the growth rates of the gross output by 1998 are divided into separate components due to changes in some input. The graphic presentation of this information clearly demonstrates the dynamic structural changes in the Russian economy (Fig. 6). As can be seen, a drastic change in the growth structure, which is also different from the structure of growth in subsequent years, occurred in 1999. It was the first year of growth and was simultaneously accompanied by a decline in the household consumption. The growth was due to sharply shrinking imports and a significant increase in exports.

Then, the transformation of the contribution made by household consumption, exports, and imports is of

Table 8. Impact of macrostructure factors on increase in GDP, billion rubles

Indicator	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Increase in output relative to 1990	1848.9	5746.3	8153.2	10505.7	14599.6	19000.4	22458.8	28185.5	34387.4	38285.6	31834.7	35772.8	39479.5	42608.9
Including due to														
changes in the input coefficients	−1341.0	−2421.5	−2630.6	−2871.0	−2805.6	−3059.9	−3642.1	−3927.6	−3993.2	−3750.4	−3212.5	−3239.1	−3216.5	−3365.6
household consumption	−525.6	1066.6	3178.7	5175.7	7195.4	10513.8	14101.9	18113.8	23673.1	28486.9	25705.8	28651.6	32042.1	35994.2
public consumption of fixed capital	78.4	344.5	924.4	1276.2	1657.2	1894.9	1907.1	2352.5	2453.6	2504.2	1910.8	1989.6	2181.5	2072.6
fixed capital formation	496.4	1823.3	2687.0	2864.5	4144.0	5482.3	6605.1	8663.2	11706.0	13518.3	10984.1	11800.0	13278.4	14373.5
stock gain	37.6	2626.1	2835.8	2684.7	2959.4	3939.6	4705.0	6660.3	9708.4	11670.0	−84.1	5635.7	11088.5	12843.3
exports	1631.7	3182.4	3874.3	5728.0	8168.9	10710.4	12245.1	14178.0	15771.3	16146.8	15008.9	17175.2	17097.7	17265.7
imports	1471.4	−875.2	−2716.5	−4352.4	−6719.7	−10480.8	−13463.3	−17854.8	−24931.9	−30290.2	−18478.2	−26240.2	−32992.2	−36574.9

Table 9. Share of factors of final demand and input–output coefficients in the volume of the output increase accumulated since 1998, %

Factor	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Change in the input–output coefficients	–72.5	–42.1	–32.3	–27.3	–19.2	–16.1	–16.2	–13.9	–11.6	–9.8	–10.1	–9.1	–8.1	–7.9
Household consumption	–28.4	18.6	39.0	49.3	49.3	55.3	62.8	64.3	68.8	74.4	80.7	80.1	81.2	84.5
Public consumption	4.2	6.0	11.3	12.1	11.4	10.0	8.5	8.3	7.1	6.5	6.0	5.6	5.5	4.9
Fixed capital formation	26.9	31.7	33.0	27.3	28.4	28.9	29.4	30.7	34.0	35.3	34.5	33.0	33.6	33.7
Stock gain	2.0	45.7	34.8	25.6	20.3	20.7	20.9	23.6	28.2	30.5	–0.3	15.8	28.1	30.1
Exports	88.3	55.4	47.5	54.5	56.0	56.4	54.5	50.3	45.9	42.2	47.1	48.0	43.3	40.5
Imports	79.6	–15.2	–33.3	–41.4	–46.0	–55.2	–59.9	–63.3	–72.5	–79.1	–58.0	–73.4	–83.6	–85.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

special interest. At first, before 2003, the contribution of exports exceeded the contribution of the household consumption (HC). At the same time, since 2000, the contribution of imports becomes negative, and although this negative contribution is growing, it does not pose a threat to economic growth.

Since 2005, the contribution of HC increasingly exceeds the contribution of exports. At the same time, HC is increasingly based on imports.

The redistribution of the contribution to economic growth in favor of consumption with the increasing negative role of imports that undermined the performance of the Russian economy. It should be recalled that the growth rate of the Russian economy in 1999–2008 was about 7%. At the same time, in subsequent years (2009–2016), the growth rate was less than 1.5%. Thus, based on the obtained results, we can conclude that the problems of violating the mechanism of economic growth did not arise in 2009 or 2008, but rather as far back as in 2005.

The above results are of a very general nature and only demonstrate a fraction of the capabilities offered by the developed analytical toolkit. Meaningful statements of the analytical problem that can be imple-

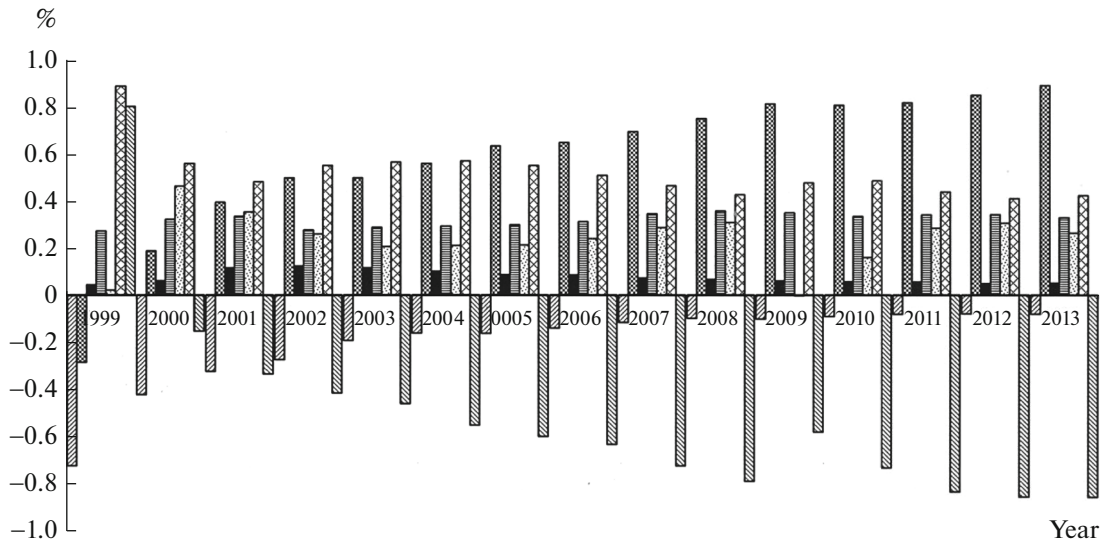

Fig. 6. Share of factors of final demand and input–output coefficients in the volume of the output increase accumulated since 1998: ▨ change in the input-output coenfficients; ▪ household consumption; ■ public consumption; ▤ fixed capital formation; ⊡ stock gain; ⊠ export; ▧ imports.

Table 10. Contributions of factors of final demand and input–output coefficients to the dynamics of gross output increase, p.p.

Indicator	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Increase in the gross output since 1990	104.0	112.0	118.0	123.0	132.0	141.0	149	161	174	183	169	177	185	192
Including due to														
changes in the input coefficients	−75.4	−47.4	−37.9	−33.5	−25.3	−22.7	−24.1	−22.4	−20.2	−17.9	−17.0	−16.1	−15.1	−15.2
household consumption	−29.6	20.9	45.9	60.4	64.8	78.1	93.3	103.4	120.0	136.0	136.3	142.0	150.4	162.2
public consumption	4.4	6.7	13.3	14.9	14.9	14.1	12.6	13.4	12.4	12.0	10.1	9.9	10.2	9.3
fixed capital formation	27.9	35.7	38.8	33.5	37.3	40.7	43.7	49.5	59.3	64.5	58.2	58.5	62.3	64.8
stock gain	2.1	51.4	40.9	31.4	26.7	29.2	31.1	38.0	49.2	55.7	−0.4	27.9	52.0	57.9
exports	91.8	62.3	55.9	66.9	73.6	79.5	81.0	80.9	79.9	77.1	79.6	85.1	80.3	77.8
imports	82.8	−17.1	−39.2	−50.8	−60.5	−77.8	−89.0	−101.9	−126.4	−144.6	−98.0	−130.0	−154.9	−164.9
Total	104.0	112.4	117.6	422.7	131.5	141.1	148.5	160.9	174.3	182.7	168.8	177.3	185.3	192.1

mented within the proposed system of calculations can include the following:

—analyze the impact of technological changes in the economy on the development of individual industries, including production dynamics and the level of profitability;

—analyze the impact made by technological changes in a particular industry on the growth in the industry itself and in the economy as a whole;

—analyze the consequences of changes in the energy intensity of the Russian economy;

—analyze the consequences of technological changes in resource-consuming industries (investigation into the consequences of changes in the rows of the matrix of input–output coefficients);

—analyze the impact of changes in individual technological coefficients on the sectoral dynamics and the performance of the economy as a whole;

—analyze the impact made by indirect technological changes on the industry (change in input–output coefficients outside the row and column that describe the industry);

—analyze the impact of individual components and elements of the final demand on the dynamics in the development of industries;

—analyze the impact made by various combinations of changes in final demand and the matrix of input–output coefficients on the dynamics and structure of the outputs;

—conduct a retrospective investigation of the effect produced by the elasticities of interbranch links, including the periods of recession and recovery growth.

The above-listed input–output analysis, and possibly others, can be the subjects of further research.

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