ESTIMATE OF AN AVERAGE SITUATION OF REGIONS IN VALUE CHAINS

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Abstract
The article considers an indicator that reflects an average position of industries and regions in value chains. It shows high differentiation of territorial distribution of its values in Russian economy. It determines a strong correlation between GRP per capita and an upstreamness index in the economy of Russian regions. The paper compares obtained results with the data on US economy.

Keywords: region, upstreamness, value chains, GRP
JEL classification: O18

1. Introduction

The market reforms carried out in Russia have resulted in the decreased length of technological chains in the economy by 2–3 process stages. Revenues of the state, companies and population are reduced and consumer demand and investment opportunities are decreased due to lost value added. Profit-taking at the stage of raw materials extraction and semi-finished products manufacture leads to depression in manufacture of final products, degradation of machinery production and decline in domestic demand for basic and applied science, research and development, scientific and technological progress, deterioration of a material and technical base of education and health care, and lower qualification of personnel – the country falls into a spiral of backwardness and decomposition (Gubanov, 2017). In this regard, the extension of value added chains (VAC) in the national economy is one of the most important directions of modern economic policy (Gubanov, 2017; Ilyin, Povarova, 2014; Mikulsky, 2017). At the same time, the implementation of such a policy is impossible without an analysis of the current situation of regional economies (the importance of a regional level is related to the management aspect of economic policy implementation; regional authorities are its important subject) in the existing VAC, which is the purpose of this study.

2. Research methods

The indicator called upstreamness is used in English literature to characterize an average position of a certain industry in the VAC. Its value for an *i*-industry reflects a weighted average number of production stages to the final demand of industries, in which the *i*-product is a component (Kuznetsov, Sedalishchev, 2018).

If we consider a region's economy as a set of industries, than the use of this indicator, with a share of industries in the economy being taken into account, characterizes a region's position in the VAC.

For the first time the method of calculating upstreamness was proposed in (Antràs, Chor, Fally, Hillberry, 2012). We consider the logic of its construction briefly. In a closed economy for each industry $i\in\{1,2,...,N\}$, the gross output value (Y_i) is the sum of its use as a final product (F_i) and its use as an intermediate imput to other industries (Z_i):

$$Y_i = F_i + Z_i = \sum_{j=1}^{N} d_{ij} Y_j \quad , \qquad (1)$$

where d_{ij} is a quantity of an *i*-product required to produce one unit of a j-product .

Iterating this identity (1), we can express an *i*-industry's gross output as an infinite sequence of terms, reflecting the use of this industry's products in the VAC:

$$Y_i = F_i + \sum_{j=1}^{N} d_{ij} F_j + \sum_{j=1}^{N}\sum_{k=1}^{N} d_{ik} d_{kj} F_j + \sum_{j=1}^{N}\sum_{k=1}^{N}\sum_{l=1}^{N} d_{il} d_{lk} d_{kj} F_j + ... \qquad (2)$$

To calculate the average position of an industry's output in the VCA – a measure of upstreamness– the authors (Antràs, Chor, Fally, Hillberry, 2012) suggest to multiply each term in the formula (2) by the distance from final use plus one and divide by gross output of an industry Y_i:

$$U_{1i} = 1 \times \frac{F_i}{Y_i} + 2 \times \frac{\sum_{j=1}^{N} d_{ij} F_j}{Y_i} + 3 \times \frac{\sum_{j=1}^{N}\sum_{k=1}^{N} d_{ik} d_{kj} F_j}{Y_i} + 4 \times \frac{\sum_{j=1}^{N}\sum_{k=1}^{N}\sum_{l=1}^{N} d_{il} d_{lk} d_{kj} F_j}{Y_i} + \ldots \quad (3)$$

As can be seen from the formula (3), the minimum value of the indicator for a certain industry is 1. This indicator value can be observed if the entire output of an *i*-industry goes to final consumption (Kuznetsov, Sedalishchev, 2018).

The practical use of the formula (3) is complicated by infinite summation of the elements. Therefore, in the same paper (Antràs, Chor, Fally, Hillberry, 2012) the alternative version of upstreamness calculation is proposed, which gives similar results (i.e. $U_{1i} = U_{2i}$):

$$U_{2i} = 1 + \sum_{j=1}^{N} \frac{d_{ij} Y_j}{Y_i} U_{2j} \quad (4)$$

The matrix form of the equality record is usually used (4):

$$U_2 = \left[I - \Delta\right]^{-1} 1, \quad (5)$$

where I is a single matrix; Δ is a matrix, in which the element (i,j) is $d_{ij}Y_j/Y_i$; 1 is a single vector.

In the case of an open economy, upstreamness is calculated similarly by the formula (5), but with export (X_i), import (M_i) and changes in savings (L_i) in an *i*-industry being taken into account:

$$Y_i = \sum_{j=1}^{N} d_{ij} Y_j + X_i - M_i + L_i \quad . \quad (6)$$

The calculation of upstreamness according to this method was carried out by economy sectors of USA (Antràs, Chor, Fally, Hillberry, 2012), China (Chen, 2017; Ju, Yu, 2015), Poland (Hagemejer, Tyrowicz, 2017), Asia (Ito, Vézina, 2016.) and globally (Miller, Temurshoev, 2017; Beladi, Chakrabarti, Hollas, 2017). The estimation of this indicator for Russian economy branches was made by D. Kuznetsov and V. Sedalishchev (Kuznetsov, Sedalishchev, 2018).

We propose calculation of the weighted average upstreamness index for the economy (R), defined as a sum of products of upstreamness industry indicators (U_{2i}) and specific weights of industries in the gross output of an economy (w_i):

$$R = \sum_{i=1}^{N} U_{2i} \times w_i \quad . \quad (7)$$

When interpreting the results, we should take into account the following: the higher value of an upstreamness indicator indicates that an enterprise, industry, region or country produces goods that are on average more distant from final consumption, but does not allow to say that a firm, industry, region or country deals with technologically less complex stages of production (Kuznetsov, Sedalishchev, 2018). The proximity of a production stage to a consumer is not generally associated with a greater technological complexity of a production stage (Kuznetsov, Sedalishchev, 2018).

To calculate an upstreamness index for the Russian economy, we used the latest available data of the Federal State Statistic Service input – output tables in the context of 126 industries. These branches were further aggregated to 26 according to their weights in gross output. The nomenclature of industries for analysis was determined by the available data on the sectoral structure of gross output and gross value added of regional economies, presented in the statistics digest "Regions of Russia". It is important to note that indicator values depend on a number of industries in the data detail: the more industries are drilled down, the more stages of production to final consumption can be observed. Therefore, at the initial stage it is important to take the most disaggregated data, because the values of the upstreamness measure can be in a wide range within the aggregated industries. For example, in the

production of electrical equipment, electronic and optical equipment (DL for OKVED), the indicator values are in a range from 1.349 (medical products, including surgical equipment**,** ortho-pedagogical devices) to 3.420 (wires and cables isolated).

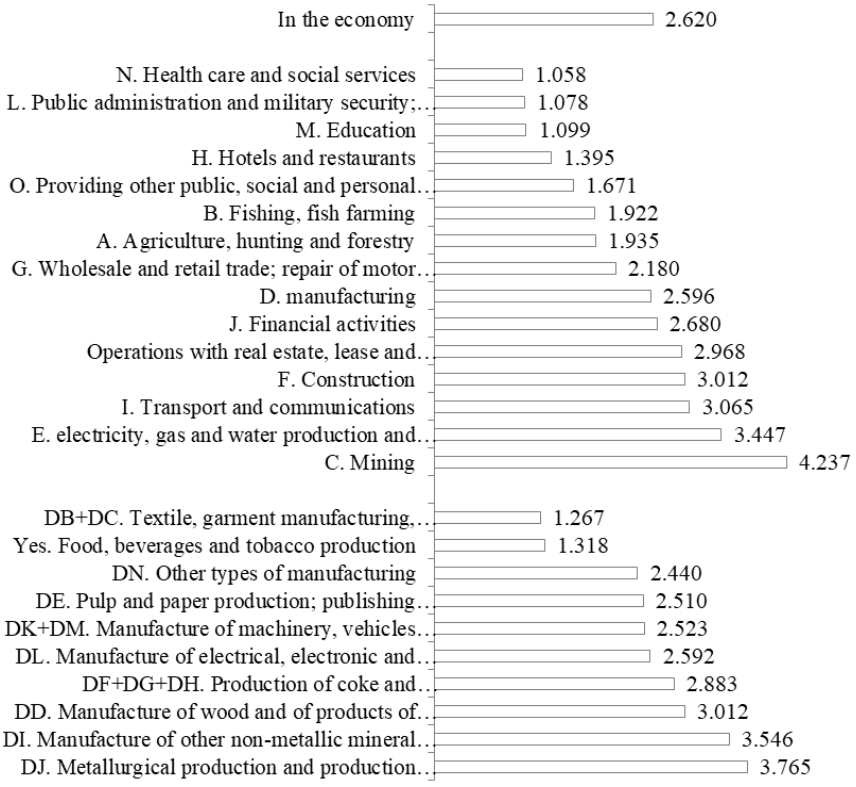
Due to the fact that the input – output tables are not developed at the regional level, the assumption of similarity of average technological processes in the same industries in the whole country and some regions was used to calculate indicators for the regions; the all-Russian upstreamness indicators for the economy sectors were taken.

To compare the achieved results with those of the United States, the data of the input – output tables and data on the structure of GRP production by states published by the U.S. Bureau of Economic Analysis (U.S. BEA) were used. Industries were aggregated to a nomenclature similar to the Russian one.

3. Results

The obtained values of the upstreamness index indicate significant difference in the position of Russian industries in the VAC. The minimum value for aggregated industries in 2015 was 1, the maximum – 4.237 (Figure 1). The industries where output is almost entirely spent on final consumption include healthcare (1.058), education (1.078) and public administration (1.099). A pronounced distance from final consumption is typical for mining (4.237), production and distribution of electricity, gas and water (3.447). Manufacturing industries are located approximately in the middle of the VAC. Among them there are least intermediate industries, such as light (1.267) and food (1.318) industries, and the most intermediate, such as metallurgy (3.765) and production of other non-metallic mineral products (3.546). This distribution of industries is generally consistent with a priori perceptions of the industry's position in the VAC.

Figure 1: Upstreamness index by Russian economy industries (kinds of economic activities) in 2015



Source: calculated on the basis of data of Federal State Statistics Service input – output tables

There is a feature of the upstreamness index that should be noted here. It correctly reflects ranking for industries, one of which is the preferred supplier of products for the other [4]. This is clearly manifested at a disaggregated level. We can consider values of the upstreamness measure of the printed production chain (Table 1) as an illustrative example. It is estimated

that the forestry (3.761) and timber (3.671) industries are considered to be less finite than the pulp and paper (2.634) industries, which in turn are further away from the final consumer than the paper (2.030) and book (1.946) industries. This kind of regularities can be traced for other technologically related sectors of the economy. This feature is extremely important for the practical use of the upstreamness index when building VAC.

Table 1.Upstreamness index of industries of the printed products manufacture chain in 2015

Product name	Value
Books, newspapers and other materials, printed and recorded media	1.946
Paper and cardboard products	2.030
Cellulose, paper and cardboard	2.634
Longitudinally sawn, planed or impregnated timber	3.671
Products of forestry, logging and related services	3.761

Source: calculated on the basis of data of Federal State Statistics Service input – output tables

A wide range of upstreamness industry indicators and different branches of specialization of Russian regions have led to a significant territorial differentiation of upstreamness values. The lowest values are recorded in the republics of Ingushetia (1.970), Tuva (1.985), North Ossetia-Alania (2.036), Altai (2.057), Kalmykia (2.098), Adygea (2.174), Dagestan (2.184), Crimea (2.209), Chechnya (2.030), Karachay-Cherkessia (2.092), Kabardino-Balkaria (2.115), Kamchatka Krai (2.135) and Stavropol Krai (2.207), the city of Sevastopol (2.014), where industry is poorly developed, the economy structure is dominated by agriculture, food industry, trade, healthcare, education and public administration sector (Table 2). The highest upstreamness values are typical for resource-producing regions – Nenets (3.744), Khanty-Mansi (3.705), Yamal-Nenets (3.508), Chukotka (3.111) autonomous okrugs, Sakhalin (3.464) and Orenburg (3.046) oblasts, republics of Sakha (3.217) and Komi (3.059). The upstreamness values in regions specializing in manufacturing industry (The share of gross value added generated by manufacturing exceeds 30% of GRP) are in the range from 2.37 to 2.76. For the Omsk Oblast the indicator value is 2.372, the Kaluga Oblast – 2.375, the Vladimir Oblast – 2.383, the Lipetsk Oblast – 2.418, the Tula Oblast –2.423, the Nizhny Novgorod –2.434, the Novgorod Oblast – 2.435, the Sverdlovsk Oblast – 2.444, the Chelyabinsk Oblast – 2.461, the Vologda Oblast – 2.476, Krasnoyarsk Krai – 2.754.

Table 2. Upstreamness indicator for Russian regions economy in 2015

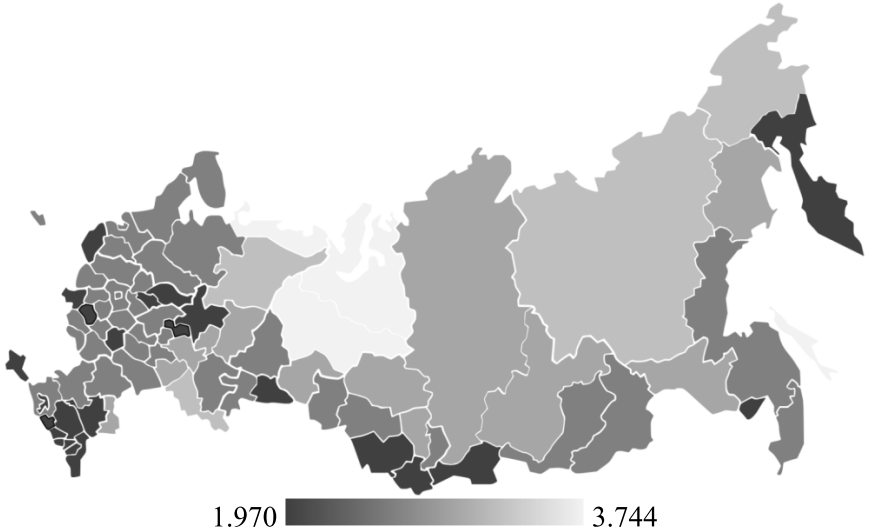
Territory	Value	Territory	Value
Republic of Ingushetia	1.970	Saint-Petersburg	2.435
Republic of Tuva	1.985	Republic of Karelia	2.437
Sevastopol	2.014	Volgograd Oblast	2.441
Republic of Chechnya	2.030	Khabarovsk Krai	2.443
Republic of North Ossetia-Alania	2.036	Sverdlovsk Oblast	2.444
Republic of Altai	2.057	Moscow	2.453
Republic of Karachay-Cherkessia	2.092	Republic of Bashkortostan	2.455
Republic of Kalmykia	2.098	Chelyabinsk Oblast	2.461
Republic of Kabardino-Balkaria	2.115	Novosibirsk Oblast	2.464
Kamchatka Krai	2.135	Zabaikalsky Krai	2.470
Republic of Adygea	2.174	Vologda Oblast	2.476
Republic of Dagestan	2.184	Kursk Oblast	2.496
Stavropol Krai	2.207	Belgorod Oblast	2.510
Republic of Crimea	2.209	Leningrad Oblast	2.550
Ivanovo Oblast	2.238	Murmansk Oblast	2.575
Pskov Oblast	2.251	Republic of Khakassia	2.617
Orel Oblast	2.256	Amur Oblast	2.685
Bryansk Oblast	2.264	Perm Oblast	2.719
Jewish Avtonomous Oblast	2.266	Samara Oblast	2.744
Altai Krai	2.272	Krasnoyarsk Oblast	2.754
Kirov Oblast	2.276	Tyumen Oblast (without JSC)	2.762
Kurgan Oblast	2.284	Astrakhan Oblast	2.783

Territory	Value	Territory	Value
Republic of Mari El	2.299	Magadan Oblast	2.786
Tambov Oblast	2.312	Udmurt Republic	2.796
Kostroma Oblast	2.317	Republic of Tatarstan	2.821
Republic of Buryatia	2.330	Kemerovo Oblast	2.843
Ryazan Oblast	2.331	Arkhangelsk Oblast (with JSC)	2.846
Republic of Mordovia	2.332	Irkutsk Oblast	2.852
Republic of Chuvashia	2.333	Tomsk Oblast	2.936
Penza Oblast	2.338	Orenburg Oblast	3.046
Arkhangelsk Oblast (without JSC)	2.360	Komi Republic	3.059
Rostov Oblast	2.363	Chukotka Autonomous Okrug	3.111
Primorsky Krai	2.369	Sakha (Yakutia) Republic	3.217
Omsk Oblast	2.372	Sakhalin Oblast	3.464
Kaluga Oblast	2.375	Tyumen Oblast (with JSC)	3.501
Voronezh Oblast	2.377	Yamalo-Nenets Autonomous Okrug	3.508
Krasnodar Oblast	2.381	Khanty-Mansiysk AO-Yugra	3.705
Vladimir Oblast	2.383	Nenets Autonomous Okrug	3.744
Saratov Oblast	2.384		
Smolensk Oblast	2.388	North Caucasian Federal District	2.150
Moscow Oblast	2.401	Southern FD	2.412
Ulyanovsk Oblast	2.414	Central Federal District	2.429
Tver Oblast	2.415	Northwestern Federal District	2.542
Kaliningrad Oblast	2.416	Volga Federal District	2.624
Lipetsk Oblast	2.418	Siberian Federal District	2.644
Tula Oblast	2.423	Far Eastern Federal District	2.859
Yaroslavl Oblast	2.431	Ural Federal District	3.133
Nizhny Novgorod Oblast	2.434		
Novgorod Oblast	2.435	Russian Federation	2.620

Source: calculated on the basis of Federal State Statistics Service data.

The geographical distribution of regional upstreamness indicators across the country is shown in Figure 2. We can identify a decrease in their values from the North to the South and from the East to the West and focus on crowded places as a final consumer.

Figure 2: Upstreamness indicator for Russian regions economy in 2015



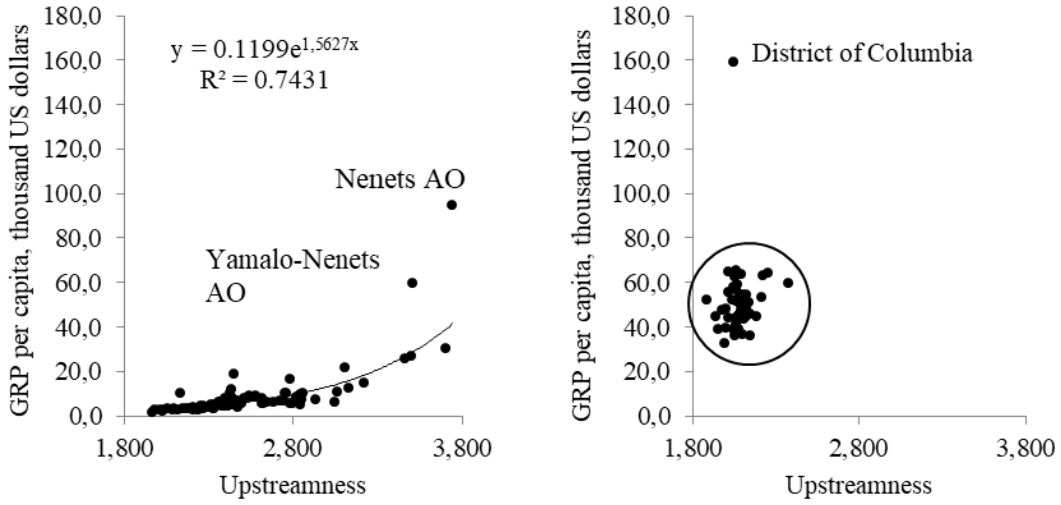
Source: calculated on the basis of Federal State Statistics Service data

As for Russian regions, there is a strong positive correlation between an upstreamness value of their economy and a volume of GRP per capita – high upstreamness values correspond to high values of GRP per capita (Figure 3a). That is, in the Russian economy there is a paradoxical situation when the farther the region in the VAC from the end

consumer, the more intermediate product it produces, the higher the gross income of its economy. The reasons for this lie in structural changes in the regions' economy caused by the current economic model: the growth is largely determined by results of export-import activity and external environment. The greatest benefit goes to exporters of products of low added value; products of own high value added (primarily engineering) are not required in the economy.

For comparison, Figure 3b illustrates the situation in the US economy. In the absence of strong differentiation between states, there is no correlation between a volume of GRP per capita and an upstreamness value. By GRP per capita in 2015 (excluding Columbia County) the gap between the maximum (67.6 thousand US dollars in North Dakota) and minimal (31.7 thousand US dollars in Mississippi) value was 2.1 times (4.9 times for Columbia County). By upstreamness the gap between the maximum (2.376 in Wyoming) and the minimum (1,886 in Hawaii) value was 1.3 times. In Russia, respectively, it amounted to 15.2 (excluding autonomous okrugs of Arkhangelsk and Tyumen oblasts; with their account it is 54.5 times) by GRP per capita and 1.9 times by upstreamness value.

Figure 3: Correlation between GRP per capita and an upstreamness indicator for economies of regions in Russia (a) and the USA (b) in 2015

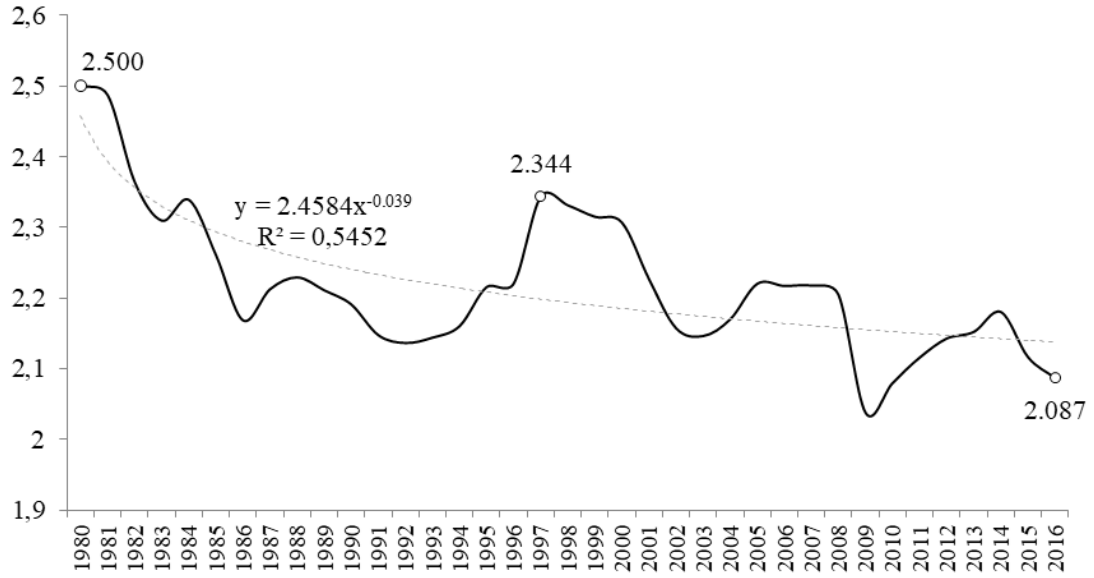


Note: For better clarity the scales on both charts are the same; GRP of Russian regions is recalculated in dollars at the average annual rate of 2015

Source: calculated on the basis of Federal State Statistics Service and .the U. S. BEA

However, the structural changes in US economy (the analysis and justification of the causes of which are beyond the scope of this article) lead to a systematic decrease in the upstreamness index (Figure 4). This is the trend of the last 20 years of their economy development.

Figure 4: Dynamics of the upstreamness index in the US economy in 1980–2016



Source: calculated on the basis of the U.S. BEA input – output tables

4. Conclusion

In terms of growing interest in the processes of building long value chains in the Russian economy there is a need to have an indicator that can quantitatively characterize processes of regional fragmentation of production. In this paper we consider and calculate the upstreamness index, which characterizes an average position of industries and regions in the VAC. The high differentiation of territorial distribution of its values in the Russian economy is shown. On the basis of empirical data the strong correlation between GRP per capita and upstreamness in the economy of Russian regions is substantiated.

Further research will involve methodological and analytical support of the use of this indicator in the practice of public administration. It is necessary to analyze relations between regions' economic development, their place in the VAC, budget financing, a level and quality of life of population, cost of science and technology, assessment of dynamics of these indicators, and compare acquired results with data on developed countries. It is important to consider clustering of regions by branches of specialization and upstreamness index values, as well as develop state policy directions on extension of national value chains. To improve the accuracy of upstreamness indicator assessment, it is reasonable to develop tools for obtaining and using disaggregated data on a production structure of regions and municipalities. In addition, since the development of regional input-output tables is unlikely to be expected in the near future, it is desired to work out methods for regionalization of all-Russian indicators in order to enhance the accuracy of calculations.

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