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Multipliers in the Analysis of Interregional Interactions

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Abstract. Institute of Economics and Industrial Engineering of the SB RAS actively uses multiregional input-output models (MRIOMs) to build long-term macroeconomic forecasts for the development of the spatial economy of the Russian Federation. In addition to the fact that static MRIOMs serve as the basis for semi-dynamic ones, they allow us to give quantitative estimates of the interactions of regions, the degree of their interdependence and complementarity. The article discusses the problems of measuring the spatial multiplier effects of economic activity. To obtain more informative estimates, we conduct a retrospective multiplicative analysis – a comparison of the state of the economy in 2007 and 2015. To calculate the multipliers, we transform the MRIOM, built in the context of eight federal districts, into a three-zone Moses-Chenery multiregional input-output model. As a result, we obtained estimates of spatial direct-effect and final-demand multipliers, on the basis of which the structures of creation and use of products by region were determined. Based on the estimates obtained, we made conclusions about the significance of the regions under study.

Keywords: spatial economy, multiregional input-output models, multiplier effects, interregional interactions.

Research area: economics.

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Мультипликаторы в анализе межрегиональных взаимодействий

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Аннотация. Оптимизационные многорегиональные межотраслевые модели (ОМММ) активно используются в ИЭОПП СО РАН для построения долгосрочных макроэкономических прогнозов развития пространственной экономики РФ. Помимо того что статические ОМММ служат базой для полудинамических, они позволяют дать количественные оценки взаимодействий регионов, степени их взаимозависимости и взаимодополняемости. В статье рассматриваются проблемы измерения пространственных мультипликативных эффектов экономической деятельности. Для получения более информативных оценок авторами статьи проводится ретроспективный мультипликативный анализ – сравнение состояний экономики в 2007 и 2015 гг. Для расчёта мультипликаторов производится трансформация ОМММ, построенной в разрезе восьми федеральных округов, в трёхзональную модель многорегионального межотраслевого баланса (МРМОБ) Мозеса-Ченери. В результате получены оценки пространственных мультипликаторов прямых и полных затрат, на базе которых определены структуры создания и использования продукции по регионам. На основе полученных оценок сделаны выводы о значимости исследуемых регионов.

Ключевые слова: пространственная экономика, многорегиональные межотраслевые модели, мультипликативные эффекты, межрегиональные взаимодействия.

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Introduction

The authors of the article developed an algorithm for information content and construction of static multiregional input-output models (MRIOMs) (Ershov et.al., 2021). The purpose of the study was to create a basis for the subsequent development of semi-dynamic MRIOMs, which are actively used by the Institute of Economics and Industrial Engineering of the SB RAS to develop strategies for long-term economic growth.

In addition to the fact that static MRIOMs serve as the basis for semi-dynamic ones, they allow us to assess the current state of the economy using multipliers. This study addresses the **problem of measuring the multiplicative effects of economic activity**. First of all, we define **the multiplicative effect** as the reaction of the economy to a change in the need in one of the industries, and the numerical value of the multiplier effect as **a multiplier**. The multiplier shows what the reaction of all sectors of the economy will be if the need in one industry changes by 1 unit. If the need is to increase output, then we are talking about a *direct-effect multiplier*. If the need is to increase the final product, then we are talking about a *final-demand multiplier*.

The reaction of the economy is understood as the increase in various types of costs necessary to meet the need in one industry. These include material, labor, capital, etc. expenses. If the response is to increase material costs (production volumes) in order to increase the output of the corresponding industry by 1 unit, then we are talking about a direct-effect multiplier of material costs. If the reaction consists in increasing material costs (production volumes) in order to increase the final product of the corresponding industry by 1 unit, then we are talking about a final-demand multiplier of material costs.

Input-output multipliers are actively used in domestic practice to determine the production load on the environment (Tagaeva, et al., 2019; Gil'mundinov, et al., 2020), to determine the consequences of the implementation of large investment projects (Shirov, Yantovsky, 2011), to determine the effects of government incentives (Evstratov, et al., 2016; Ponomaryov, Evdokimov, 2020), to determine the level of import dependence of industries (Sayapova, 2013). Unlike national input-output models, MRIOMs reflect not only input-output relations, but also make it possible to determine the levels of interregional contributions and interdependence of regions. We define such indicators as **spatial multipliers**.

In addition to input-output links, spatial multipliers are able to reflect the effects that arise in the process of interaction between regions. Thus, we define the **intraregional multiplier** as the numerical value of the reaction of the economy of this region to the change in the need of the industry of this region, and the **interregional multiplier** as the numerical value of the reaction of the economy of other regions to the change in the need of the industry of this region. In sum, these multipliers give a **national multiplier** – the numerical value of the reaction of the country's economy to a change in the need of the industry in this region.

Structural shifts in the economy have a huge impact on the value of multipliers, so the assumption in input-output models of the invariance of structural parameters is a limitation of the use of this toolkit (Shirov, Yantovsky, 2011; Ksenofontov, et al., 2018; Ponomarev, Evdokimov, 2020). For this reason, retrospective multiplicative analysis provides more informative results. **The purpose** of the study is **to compare the state of the multiregional economy of the Russian Federation for the period 2007–2015 using spatial multipliers**. The source of data for the study is MRIOMs constructed in the context of federal districts (FD) of the Russian Federation for 2007 (MRIOM-2007) and 2015 (MRIOM-2015).

Theory: literature review and research methodology

MRIOM's peculiarities

The MRIOM is a linear programming problem[1], whose solution is values of regional outputs (x_i^r), regional exports and imports (x_i^{rs} and x_i^{sr}), regional final consumption volumes (z^r) and national final consumption volume (z). An important feature of MRIOM is the consideration of inter-regional interactions, which were subject to several assumptions. Their list includes the network (border) principle of trade and the absence of counter deliveries.

In MRIOM the structure of the spatial distribution of the regional product is not set exogenously, so it belongs to the class of multiregional rather than interregional models (Oosterhaven, 2014). Thus, spatial multipliers are not presented explicitly, which requires additional transformations and calculations. For «multiplicative adaptation» of MRIOM, several approaches are possible. The first group of methods is based on the transformation of the original model to an interregional form. The second group of methods consists in the use

[1] Full statement of MRIOM is in Appendix or in our previous article (Ershov et.al., 2021).

of multiregional input-output models in which multipliers are explicitly set. The following section describes each method in detail.

Approaches based on interregional models

To understand the general logic, consider as an example the location quotients (LQ), which reflect the specialization of a region relative to a country. If the value of the LQ for region *r* is greater than one, then region *r* is more specialized than the country and can satisfy its demand at its own expense. Otherwise, region *r* needs to supply products from other regions. Consequently, the proportions of the spatial distribution of the region's products can be described by the following expression:

$$a_{ij}^{rr} = \begin{cases} LQ_i^r a_{ij}^n, if\ LQ_i^r < 1 \\ a_{ij}^n, if\ LQ_i^r > 1 \end{cases}$$

$$a_{ij}^{sr} = \begin{cases} (1 - LQ_i^r) a_{ij}^n, if\ LQ_i^r < 1 \\ 0, if\ LQ_i^r > 1 \end{cases}$$

The literature suggests several variations of the location quotients:

- Simple Location Quotient (West, 1980);
- Purchase-Only Location Quotient (Tiebout, 1969);
- Cross Industry Location Quotient (Schaffer & Chu, 1969; Morrison & Smith, 1974; Brand, 1997);
- Flegg Location Quotient (Flegg & Webber, 1996a; Flegg & Webber, 1996b; Flegg & Webber, 2000; Tohmo, 2004).

Thus, the estimation of interregional contributions occurs using the national input-output table and the values of regional outputs, which are the decision of the MRIOM. However, the doubtfulness of the application of such a method of regionalization is caused by the asymmetry of direct-effect coefficient adjustments (if $LQ_i^r > 1$, then there is no increase in coefficients).

In addition to the location quotients, there is a group of methods that similarly determine the spatial contributions by adjusting the national coefficients. These include Commodity Balance approaches (Bonfiglio, 2005; Round, 1972), Regional Purchase Coefficients (Stevens, et.al., 1983), Regional Supply Percentages (Miller, 1957; Miller & Blair, 1985), Supply-Demand Pool (Moore & Petersen; 1955), etc.

The limitation of the presented approaches lies in the possibility of their use only for the economy of two regions. In the case of a multiregional economy, these methods are able to quantify how much a region produces on its own (a_{ij}^{rr}) and how much other regions produce for it (a_{ij}^{sr}). The influence of one region on other (a_{ij}^{rs}) interregional models does not allow to determine, therefore, in our case, it is impossible to use the appropriate tools.

Approaches based on multiregional models

As part of a multiregional approach, **the multiregional input-output Moses-Chenery model** can be used (in matrix form):

$$X = GAX + GY$$

Here *X* и *Y* – column vectors (compositions of X^r and Y^r vectors, respectively) of dimension (*m* × *n*); *A* – quasi-diagonal matrix of dimensions (*m* × *n*)× (*m* × *n*), whose diagonal blocks are regional matrices of direct-effect coefficients A^r; *G* – matrix of dimensions (*m* × *n*)× (*m* × *n*) of trade coefficients[2] g_i^{rs}:

$$g_i^{rs} = \frac{x_i^{rs}}{x_i^s - S_i^s}$$

Multiplying the matrices *G* and *A*, we obtain:

$$X = QX + GY$$

Q is a matrix of direct-effect coefficients of the multiregional input-output balance. The coefficient q_{ij}^{rs} characterizes the costs of production of the industry *i* of region *r* required to produce a unit of output of the industry *j* of region *s*. Thus, *Q* is a **matrix of spatial direct-effect multipliers of material costs**.

Expressing the regional output, we get:

$$X = (E - Q)^{-1} GY = BY = (G^{-1} - A)^{-1} Y$$

B is a matrix of final-demand coefficients of the multiregional input-output balance. The coefficient b_{ij}^{rs} characterizes the costs of production of the industry *i* of region *r* necessary for the final use of a unit of production of the

[2] S_i^r – net outflow of sector i products in region r

industry j of region s. Thus, B is a **matrix of spatial final-demand multipliers of material costs**.

In matrices Q and B, diagonal elements are intraregional multipliers, off-diagonal elements are interregional multipliers, and column sums are national multipliers.

It is easy to see that in order to evaluate multiplicative effects, it is necessary to know the trading coefficients. The MRIOM solution makes it possible to calculate them, but there are other approaches to their determination, for example, the gravity method [Black, 1972; Zhuoying, 2007]. The complexity of applying this method is due to the fact that gravity models depart from the network principle of trading.

Research methodology

The Moses-Chenery model (described above) was chosen to determine the spatial multipliers. Taking into account the fact that the branches of the Russian economy are economic, the formulation of the model is as follows (this is also taken into account in the MRIOM):

$$KX = GAX + GY$$

where: k_{ij} – share of product i in sector j mixed outputs in region r.

An important assumption of the Moses-Chenery model is the possibility for a region to outflow its own products (including the region's imports). However, if there is a transit region, this premise is violated, which can lead to absurd results (negative trade coefficients).

Under the assumption that there are no counter flows (balance trading), a sufficient condition for the adequacy of the results of the Moses-Chenery model is a system of regions in which each region borders on each (in this case, there will be no transit region). For this reason, the original FD system was transformed into a three-regional system "West" – "Center" – "East". The "West" includes the Central Federal District and the North-West Federal District, the "Center" – the Southern Federal District, the North Caucasus Federal District and the Volga Federal District, the "East" – the Ural Federal District, the Siberian Federal District and the Far Eastern Federal District.

The research includes three stages. At the first stage, trade coefficients were calculated, which makes it possible to analyze both the direction of commodity flows and the level of interregional dependence. It is easy to guess that, depending on the direction of commodity flows of the three regions, six types of interregional interactions can be distinguished, presented in Table 1 (we define a "**donor region**" as a region that supplies its products to other regions of the system).

On the basis of the obtained matrix of trade coefficients at the second stage, the direct-effect and final-demand multipliers were estimated. At the end of the study, tables of the produce and use of regional products are constructed, which actually reflect information about the contributions of some regions to the economy of others.

Results

Trade directions

In Table 2 shows the changes in the directions of interregional supplies that occurred over the period 2007–2015.

Table 1. Typology of interregional interactions

Type	Description
1	The West supplies its products to the Center and the East
2	The West and the Center supply their products to the East
3	West and East supply their products to the Center
4	The Center supplies its products to the West and East
5	The East supplies its products to the Center and the West
6	Center and East supply their products to the West

Table 2. Directions of interregional supplies by industry

Sector	2007	2015
Agriculture and hunting	**6**	**4**
Forestry	5	5
Fishing, fish farming	5	5
Coal mining	5	5
Oil mining	5	5
Gas mining	5	5
Mining of ores of ferrous metals	1	1
Mining of non-ferrous metal ores	**6**	**5**
Mining of other minerals	5	5
Food industry	1	1
Light industry	**2**	**1**
Woodworking	1	1
Pulp and paper industry	1	1
Publishing and printing	1	1
Coke	**5**	**3**
Oil products	**4**	**6**
Chemical production	**4**	**1**
Other non-metallic mineral products	**2**	**1**
Ferrous metals	5	5
Non-ferrous metals	5	5
Finished metal products	**2**	**1**
Machine-building	**2**	1

In general, there were no significant changes in the directions of interregional supplies. Consider the main features of trade flows inherent in each of the regions of the system:

1. The "donation" of the East is observed for fuel and energy minerals, which is due to its high mining potential: more than 90 % of the coal mining industry of the Russian Federation (at the expense of the Siberian Federal District) and more than 75 % of the oil and gas industry of the Russian Federation (at the expense of the Ural Federal District) are concentrated in the East. Against the backdrop of a huge raw material base, ferrous and non-ferrous metallurgy is flourishing in the East (in the Ural Federal District and the Siberian Federal District, respectively).

2. The "donation" of the West is observed for the products of some manufacturing industries. The largest forest complex is located in the Northwestern Federal District, which contributes to the development of the woodworking and pulp and paper sectors. As for the food and light industry, the main part of the products of these industries is imported, while the main import activity is shown by the Central Federal District (Moscow) and the North-West Federal District (St. Petersburg).

3. The "donation" of the Center is observed in 2007 in the oil products and chemical industries. During 2007–2015 the Center's share in the output of the relevant branches of the Russian Federation was approximately 50 % for each of them. However, in 2015 the Center was already importing chemical products from the West, which is associated with the import substitution of the relevant goods (almost all the results of foreign trade activities are recorded

in the Central Federal District and the Northwestern Federal District). If in 2007 the share of imports in consumption was 18.2 %, then by 2015 it increased to 43.6 % (for chemical products).

Direct-effect and final-demand costs

Let us consider the structure of direct costs of the regions of the Russian Federation in the sectoral context. Of course, it is difficult to present the results of the calculations in full because of their volume. Therefore, a choice was made to calculate the total interregional costs for 11 industries that have the largest shares in the structure of final consumption of the Russian Federation. In Table 3 shows the values of the direct-effect multipliers for 2007–2015.

We interpret the results obtained using the example of the oil mining sector for the West in 2007. The value of 0.199 is the national direct-effect multiplier of the Western oil mining industry: it shows by how many rubles material costs will increase in the country (total for all industries) if the demand for output of the corresponding industry of the West increases by 1 ruble. Of these 0.199, the West carries 0.184 (intraregional multiplier), and the rest is distributed between the Center and the East (interregional multipliers).

Analyzing the spatial direct-effect multipliers, one can notice a high proportion of "foreign" regions in some industries. For example, in the Center's oil products sector in 2007, the share of the East (in the structure of material costs) was approximately 30 %, which is explained by large volumes of oil production in the East and its shortage in the Center. However, in 2015, the share of the East in the relevant industry of the Center was only 9 %, which is explained by the reduction in direct oil costs for the production of petroleum products.

Next, we analyze the final-demand multipliers. In Table 4 shows the values of the final-demand multipliers for 2007–2015.

We interpret the results obtained using the example of the oil mining sector for the West in 2007. The value of 1.441 is the national final-demand multiplier of the oil mining industry of the West: it shows how many rubles the material costs will increase in the country (total for all industries) if the demand for the final product of the corresponding industry of the West increases by 1 ruble. Of these 1.441, the West carries 0.499 (intraregional multiplier) and the rest is distributed between the Center and East (interregional multipliers).

Analyzing the spatial final-demand multipliers for the Western oil mining industry in 2007, one can find a high share of the East (approximately 63 %), which is explained by the peculiarities of registering the results of the foreign trade activity of the Russian Federation (the main part of oil and gas exports belongs to the Central Federal District – the city of Moscow). In 2015 the share of the East in the corresponding industry of the West increased to 86 %.

If we talk about the changes that have taken place in 2007–2015, we can see a reduction in the coefficients for service industries (real estate, education, healthcare). Of course, there's a lot to be said about the differences between 2007 and 2015, but don't dwell on it.

Production and distribution of products by region

The estimated spatial multipliers allow us to proceed to the final of the study – to the analysis of production and distribution of the produced product between regions. This approach really makes it possible to determine the contributions of some regions to others, since here the scales of production and consumption are already taken into account (in contrast to the previous stages, where specific values were considered – the direct-effect and final-demand coefficients).

Consider the structure of product use in 2007–2015. To do this, let's take the 1st and 2nd quadrants of the regional input-output tables. The evaluation results are presented in Table 5.

Considering the patterns of using regional products, it is easy to see that the most "generous" region of the Russian Federation is the East in 2007, the East allocated 14.5 % of its output to the needs of other regions, and 14.8 % in 2015. This region transported the largest share of its products to the West for final use – which is quite expected, given the raw material nature of Russia's exports. It is also worth not-

Table 3. Direct-effect multipliers in 2007 and 2015

Region		**West**					**West**			
Sectors		*West*	*Center*	*East*	***Total***		*West*	*Center*	*East*	***Total***
Agriculture		0.393	0.071	0.003	***0.467***		0.450	0.055	0.004	***0.509***
Oil mining		0.184	0.003	0.012	***0.199***		0.204	0.000	0.050	***0.255***
Food products		0.570	0.074	0.004	***0.647***		0.713	0.078	0.002	***0.793***
Light products		0.617	0.011	0.002	***0.630***		0.642	0.009	0.001	***0.652***
Oil products		0.375	0.002	0.546	***0.924***		0.350	0.055	0.348	***0.753***
Chemical products	2007	0.659	0.023	0.022	***0.704***	2015	0.653	0.027	0.022	***0.702***
Machine-building		0.677	0.006	0.025	***0.707***		0.676	0.002	0.037	***0.715***
Electricity		0.550	0.013	0.144	***0.707***		0.693	0.006	0.093	***0.791***
Real estate		0.336	0.004	0.002	***0.342***		0.284	0.001	0.002	***0.287***
Education		0.338	0.004	0.003	***0.345***		0.197	0.001	0.001	***0.199***
Healthcare		0.406	0.016	0.003	***0.425***		0.356	0.003	0.001	***0.360***
Region		**Center**					**Center**			
Sectors		*West*	*Center*	*East*	***Total***		*West*	*Center*	*East*	***Total***
Agriculture		0.000	0.403	0.005	***0.408***		0.025	0.395	0.001	***0.421***
Oil mining		0.000	0.197	0.009	***0.206***		0.005	0.242	0.010	***0.257***
Food products		0.003	0.571	0.010	***0.584***		0.060	0.632	0.012	***0.704***
Light products		0.000	0.539	0.003	***0.542***		0.187	0.370	0.000	***0.557***
Oil products		0.000	0.614	0.312	***0.926***		0.004	0.618	0.050	***0.672***
Chemical products	2007	0.002	0.560	0.024	***0.585***	2015	0.043	0.524	0.010	***0.578***
Machine-building		0.001	0.588	0.048	***0.637***		0.077	0.490	0.028	***0.596***
Electricity		0.000	0.468	0.122	***0.590***		0.006	0.575	0.025	***0.607***
Real estate		0.000	0.342	0.004	***0.346***		0.011	0.259	0.001	***0.271***
Education		0.008	0.313	0.004	***0.324***		0.005	0.182	0.000	***0.188***
Healthcare		0.002	0.381	0.004	***0.387***		0.022	0.270	0.001	***0.293***
Region		**East**					**East**			
Sectors		*West*	*Center*	*East*	***Total***		*West*	*Center*	*East*	***Total***
Agriculture		0.026	0.020	0.356	***0.402***		0.038	0.006	0.372	***0.417***
Oil mining		0.005	0.012	0.216	***0.233***		0.007	0.000	0.241	***0.248***
Food products		0.078	0.010	0.488	***0.576***		0.073	0.010	0.612	***0.695***
Light products		0.125	0.058	0.372	***0.554***		0.200	0.001	0.348	***0.549***
Oil products		0.004	0.005	0.921	***0.930***		0.010	0.000	0.660	***0.670***
Chemical products	2007	0.016	0.101	0.474	***0.590***	2015	0.105	0.000	0.473	***0.578***
Machine-building		0.036	0.082	0.543	***0.660***		0.114	0.000	0.490	***0.604***
Electricity		0.012	0.025	0.599	***0.636***		0.009	0.000	0.670	***0.679***
Real estate		0.017	0.015	0.308	***0.341***		0.017	0.000	0.257	***0.275***
Education		0.045	0.007	0.293	***0.345***		0.007	0.000	0.180	***0.188***
Healthcare		0.030	0.050	0.322	***0.402***		0.042	0.000	0.254	0.296

Table 4. Final-demand multipliers in 2007 and 2015

Region		West					West			
Sectors		*West*	*Center*	*East*	***Total***		*West*	*Center*	*East*	***Total***
Agriculture	2007	1.134	0.698	0.038	1.870	2015	1.452	0.521	0.042	2.014
Oil mining		0.499	0.032	0.910	1.441		0.204	0.001	1.247	1.453
Food products		1.955	0.178	0.038	2.171		2.420	0.213	0.056	2.689
Light products		1.934	0.037	0.027	1.998		2.313	0.044	0.049	2.405
Oil products		1.122	0.528	0.683	2.333		0.833	0.747	0.661	2.241
Chemical products		1.988	0.248	0.086	2.322		2.307	0.092	0.137	2.536
Machine-building		2.407	0.033	0.122	2.562		2.441	0.020	0.198	2.659
Electricity		2.144	0.047	0.246	2.438		2.362	0.026	0.242	2.631
Real estate		1.667	0.018	0.035	1.721		1.512	0.008	0.029	1.548
Education		1.656	0.025	0.033	1.713		1.376	0.009	0.022	1.407
Healthcare		1.820	0.053	0.040	1.913		1.704	0.024	0.039	1.766
Region		**Center**					**Center**			
Sectors		*West*	*Center*	*East*	***Total***		*West*	*Center*	*East*	***Total***
Agriculture	2007	0.004	1.731	0.040	1.776	2015	0.108	1.718	0.022	1.849
Oil mining		0.012	0.870	0.534	1.416		0.030	1.374	0.051	1.456
Food products		0.020	1.874	0.048	1.942		0.726	1.704	0.052	2.483
Light products		0.004	1.477	0.025	1.506		1.733	0.558	0.042	2.333
Oil products		0.012	1.844	0.457	2.313		0.040	2.002	0.116	2.158
Chemical products		0.013	1.955	0.096	2.063		0.399	1.786	0.069	2.254
Machine-building		0.026	2.121	0.197	2.345		0.708	1.534	0.155	2.398
Electricity		0.012	1.941	0.223	2.176		0.051	2.082	0.092	2.225
Real estate		0.006	1.632	0.048	1.686		0.052	1.417	0.017	1.486
Education		0.024	1.567	0.039	1.630		0.031	1.313	0.012	1.356
Healthcare		0.009	1.717	0.047	1.773		0.088	1.489	0.021	1.597
Region		**East**					**East**			
Sectors		*West*	*Center*	*East*	***Total***		*West*	*Center*	*East*	***Total***
Agriculture	2007	0.205	0.088	1.663	1.956	2015	0.155	0.077	1.623	1.855
Oil mining		0.027	0.044	1.388	1.459		0.042	0.001	1.406	1.449
Food products		0.974	0.129	1.436	2.539		0.875	0.089	1.531	2.494
Light products		2.573	0.731	2.236	5.541		1.689	0.034	0.606	2.329
Oil products		0.037	0.360	1.997	2.393		0.064	0.002	2.097	2.164
Chemical products		0.055	1.011	1.138	2.204		0.990	0.039	1.331	2.360
Machine-building		0.402	0.750	1.365	2.517		1.024	0.010	1.435	2.469
Electricity		0.079	0.106	2.176	2.361		0.076	0.001	2.414	2.491
Real estate		0.088	0.065	1.610	1.763		0.074	0.001	1.432	1.507
Education		0.151	0.049	1.597	1.797		0.041	0.002	1.332	1.374
Healthcare		0.129	0.155	1.687	1.972		0.146	0.006	1.474	1.627

Table 5. Structure of product use in 2007 and 2015

	2007						
	Intermediate cons.			***Final cons.***			**Total output**
	West	Center	East	West	Center	East	
West	46.2 %	0.2 %	1.5 %	50.7 %	0.0 %	1.4 %	100.0 %
Center	2.4 %	45.7 %	2.9 %	1.6 %	45.5 %	1.9 %	100.0 %
East	4.2 %	2.6 %	43.1 %	7.0 %	0.7 %	42.4 %	100.0 %
	2015						
	Intermediate cons.			***Final cons.***			**Total output**
	West	Center	East	West	Center	East	
West	44.6 %	1.5 %	2.0 %	48.0 %	1.8 %	2.0 %	100.0 %
Center	2.1 %	43.0 %	0.1 %	2.3 %	52.5 %	0.1 %	100.0 %
East	4.4 %	1.3 %	41.0 %	8.6 %	0.5 %	44.2 %	100.0 %

Table 6. Structures of product creation in 2007 and 2015

		Intermediate cons.					***Intermediate cons.***		
		West	Center	East			West	Center	East
2007	West	45.5 %	0.3 %	2.0 %	2015	West	43.8 %	2.6 %	2.8 %
	Center	1.3 %	45.2 %	2.2 %		Center	1.2 %	41.0 %	0.1 %
	East	2.9 %	3.2 %	41.7 %		East	2.9 %	1.5 %	40.0 %
	GVA [1]	50.4 %	51.3 %	54.0 %		GVA	52.1 %	54.9 %	57.1 %
	Total output	100.0 %	100.0 %	100.0 %		**Total output**	100.0 %	100.0 %	100.0 %

[1] GVA – Gross Value Added.

ing the Center, which in 2007 supplied 8.8 % of its own products for other people's needs. However, by 2015 the "utility" of this region decreased by about 2 times, which was caused by a reduction in the needs of the East in oil products due to a decrease in the fuel intensity of the economy and an increase in its own oil refining.

Next, consider the structure of product creation in 2007–2015. To do this, let's take the 1st and 3rd quadrants of the regional input-output tables. The evaluation results are presented in Table 6.

Considering the structures of creating regional products, it can be seen that the shares of products of "foreign" regions tend to decrease due to a decrease in the share of industry (transportable products) in total production. It is also worth noting that over the period under review, the share of GVA in the structure of production increased for all regions of the system.

Conclusion

As a conclusion, we would like to define the role of the East in the economic development of the Russian Federation. This region supplies our country with income from the export of hydrocarbons, and taking into account the fact that the nature of Russia's development is export-oriented (at the expense of oil and gas), it is worth noting the dependence of the Russian Federation on the East. Moreover, as the analysis of the structure of product use showed, the contribution of the East to other regions remained practically unchanged in 2007–2015, which indicates its long-term nature.

Thus, the use of multipliers in the study of interregional interactions makes it possible to give quantitative estimates that cannot be obtained in any other way. To achieve more accurate results, various modifications of this toolkit are possible, for example, the division of consumed products into imported and domestic ones (Granberg, 2001), as well as considering consumer demand as an endogenous component (Dondokov, 2019). In addition to modifying the instrumentation, it is possible to change the object of study, for example, to analyze the Asian part of Russia.

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Appendix

Our static multiregional input-output model sets the following linear programming problem:

- Regional equations for production and distribution of products by sectors:

$$\sum_{j=1}^{n} \boldsymbol{k}_{\boldsymbol{ij}}^{\boldsymbol{r}} x_j^r - \sum_{j=1}^{n} \boldsymbol{a}_{\boldsymbol{ij}}^{\boldsymbol{r}} x_j^r - \boldsymbol{\alpha}_{\boldsymbol{i}}^{\boldsymbol{r}} z^r - \sum_{s \neq r} x_i^{rs} + \sum_{s \neq r} x_i^{sr} - \boldsymbol{v}_{\boldsymbol{i}}^{\boldsymbol{rk}} + \boldsymbol{v}_{\boldsymbol{i}}^{\boldsymbol{kr}} \geq \boldsymbol{q}_{\boldsymbol{pi}}^{\boldsymbol{r}};$$

$i = 1, \ldots, n;$

- Constraints for the transport sector ($i = \tau$):

$$\sum_{j=1}^{n\prime} \boldsymbol{k}_{\tau \boldsymbol{j}}^{\boldsymbol{r}} x_j^r - \sum_{j=1}^{n\prime} \boldsymbol{a}_{\boldsymbol{\tau j}}^{\boldsymbol{rr}} x_j^r - \boldsymbol{\alpha}_{\boldsymbol{\tau}}^{\boldsymbol{r}} z^r - \sum_{s \neq r} \sum_{j=1}^{n\prime} \boldsymbol{c}_{\boldsymbol{r\tau j}}^{\boldsymbol{rs}} x_j^{rs} - \sum_{s \neq r} \sum_{j=1}^{n\prime} \boldsymbol{c}_{\boldsymbol{r\tau j}}^{\boldsymbol{sr}} x_j^{sr} -$$

$$- \sum_{j=1}^{n\prime} \boldsymbol{d}_{\boldsymbol{\tau j}}^{\boldsymbol{rk}} \boldsymbol{v}_{\boldsymbol{j}}^{\boldsymbol{rk}} - \sum_{j=1}^{n\prime} \boldsymbol{d}_{\boldsymbol{\tau j}}^{\boldsymbol{kr}} \boldsymbol{v}_{\boldsymbol{j}}^{\boldsymbol{kr}} \geq \boldsymbol{q}_{\boldsymbol{p\tau}}^{\boldsymbol{r}}; \boldsymbol{\tau} \in \mathrm{T}$$

- Regional constraints for employment in the economy:

$$\sum_{j=1}^{n} \boldsymbol{l}_{\boldsymbol{j}}^{\boldsymbol{r}} x_j^r \leq \boldsymbol{L}^{\boldsymbol{r}}$$

- Constrains over the spatial structure of final consumption:

$$-z^r + \boldsymbol{\lambda}^{\boldsymbol{r}} z \leq 0$$

- Regional output constraints:

$$0 \leq x_j^r \leq \boldsymbol{N}_{\boldsymbol{j}}^{\boldsymbol{r}}$$

- Non-negativity constraints over variables:

$$x_i^r, x_\tau^r, z^r, z, x_i^{rs}, x_i^{sr} \geq 0$$

- Objective function:

$$z \to max$$

Notation[3]:

Variables:

x_i^r – output of products (services) in sector *i* in region *r*;
x_τ^r – volume of transport services in region *r*;
z^r – final consumption in region *r*;
z – final national consumption;
x_i^{rs} – deliveries of sector *i* products from region *r* to region *s* (outflow of region *r*);
x_i^{sr} – deliveries of sector *i* products from region *s* to region *r* (inflow of region *r*)

Parameters:

v_i^{rk} – export of product *i* goods (services) from region *r*;
v_i^{kr} – import of product *i* goods (services) from region *r*.
k_{ij}^r – share of product *i* in sector *j* mixed outputs in region *r*;

[3] About differences between export/ import and outflow/inflow: Regional export/import means deliveries from/to region to/from the rest of the world, but regional outflow/inflow means deliveries from/to region to/from other regions.

a_{ij}^{r} – inputs from sector *i*, needed per unit of output of sector *j* in region *r*;
$a_{\tau j}^{rr}$ – transport inputs of region *r* for intra-regional deliveries of unit of products *j* in region *r*;
$c_{r\tau j}^{rs}$ – transport inputs of region *r* for outflow of unit of products *j* from region *r* to region *s*;
$c_{r\tau i}^{sr}$ – transport inputs of region *r* for inflow of unit of products *j* from region *s* to region *r*;
$d_{\tau i}^{rk}$ – transport inputs of region *r* for export of unit of products *j*;
$d_{\tau j}^{kr}$ – transport inputs of region *r* for import of unit of products *j*;

α_i^r – share of product *i* in the total final consumption in the region *r* ($\sum_{i=1}^{n} \alpha_i^r = 1$);

λ^r – share of region *r* in the total final national consumption ($\sum_{r=1}^{R} \lambda^r = 1$);

q_{pi}^{r} – volume of final product in the part of product *i* of region *r*, non-included in the maximized part of final consumption (mostly, gross accumulation of fixed capital);
l_j^r – labour inputs per unit of product *j* in region *r*;
L^r – upper limits over labor resources (number of employed) in region *r*;
N_j^r – upper limits over product output *j* in region *r*.