

Gas Industry in the Economic Space of the Russian Far East: Expectations and Reality

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Abstract — The study outlines the evolution undergone by the gas industry in the Russian Far East and reviews the main features of its resource base, transport infrastructure, and processing facilities. We analyze the goals of the Eastern Gas Program and its results achieved. We reveal that for two decades, the development of the industry was carried out in an extensive way and was subordinated to the pursuit of national interests. We consider three configurations of the gas industry in the region. The configurations are related in such a way that to arrive at the next configuration the preceding one is complemented by production facilities representing the next link of the process chain. The gas industry in its first configuration includes natural gas production and transport companies; in the second configuration - gas processing facilities; in the third configuration - gas chemical facilities. Based on the analysis of structural shifts, we show that the gas industry in the first configuration underwent development in the region at an advanced pace but remained an enclave in the structure of the economy. Estimates of the effects of sectoral superstructures in the format of the second and third configurations are projections, since the projects to build the Amur Gas Processing Plant and the Amur Gas Chemical Complex are still underway. We used an input-output model to obtain estimates of regional GRP growth rate in the case of development of these industries. It was found that the emergence of gas processing in the region's economy will increase the GRP by 11.2% compared to 2015, and the emergence of gas processing and gas chemical industries will provide a total increase in the GRP by 13.9%. According to

the results of calculations based on the dynamic model of economic interactions FrEEDM, given that all process lines of the Amur Gas Processing Plant are put into operation, the above increase in the GRP can be achieved by 2030.

Index Terms: analysis of structural shifts, Eastern Gas Program, gas processing, gas chemical industry, the Russian Far East, natural gas production, model of economic interactions.

I. INTRODUCTION

The industries of the energy sector are among the basic industries of the Russian Far East economy. Coal mining has been historically important for the region, while hydrocarbons have been used at scale only in the last two decades due. The latter is due to the depletion of the resource base in traditional mining areas and the formation of a niche for Russian energy resources in the markets of Asia-Pacific countries. To maintain its leading position in global energy markets, it is important for Russia to develop the gas industry at an accelerated pace. We have previously attempted to obtain estimates of the effects of individual projects in the gas industry of the Russian Far East, but today there is a need and opportunity to go further and generalize these estimates as part of a system-wide analysis of the role of the gas industry in the region's economy in terms of the planned and achieved results.

Estimates of the effects of the development of the gas industry of the Russian Far East are made for its three configurations. The configurations are related in such a way that to arrive at the next configuration the preceding one is complemented by production facilities representing the next link of the process chain. The gas industry in its first configuration includes natural gas production and transport facilities; in the second configuration - a gas processing plant is added to the resource base and transport infrastructure; in the third configuration - a gas chemical complex is assumed to be built. To date, the real effects can be estimated only for the first configuration, as gas processing and gas chemical projects are still underway. With this in mind the study is carried out in three stages.

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<http://dx.doi.org/10.25729/esr.2023.01.0006>

Received April 06, 2023. Revised April 25, 2023.

Accepted April 27, 2023. Available online April 30, 2023.

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The first stage outlines the projected configurations of the gas industry and describes the dynamics of the industry over the past two decades of its active development. The second stage, as part of the analysis of structural shifts, compares the industry dynamics of individual regions of the Russian Far East with the industry dynamics of the national economy and economy of its nearest environment. Based on this comparison we draw conclusions about changes in the degree of involvement of the gas industry in the structural links as part of cross-regional and cross-industry interactions. At the third stage, we make projections of the effects of establishment of gas processing and gas chemical industries in the region on the basis of an input-output model and a dynamic model of economic interactions.

II. LITERATURE REVIEW

The problem of measuring the economic effects of energy sector development (especially the development of the oil and gas industries), as well as that of determining the vector of the development path of the energy sector itself, has produced a substantial body of published research. Among the key issues discussed as part of this field of research are the following: whether the energy sector is a driver of economic growth or acts as its limitation [1-5], how efficient are the energy sector industries in comparison with other industries of the economy [4; 6], what is the nature of the relationship between economic growth and energy consumption [1; 4; 7]. At the same time, most empirical studies in this field are focused on obtaining estimates of the effects of individual major projects in the oil and gas industries as well as their impact on the dynamics of regional and/or national macroeconomic metrics [8-12].

As concerns the Russian Far East, there have been studies tracing the history of the gas industry, the specifics of its current functioning [13; 14], and estimates of the prospective contribution of projects for development of the gas processing plant [11] and gas chemical plant [12]. In addition, an attempt was made to assess the performance of the Eastern Gas Program, where a comparative analysis of the results achieved with the planned performance indicators of the program was carried out, and the factors that led to these discrepancies were identified [15].

The present study is stands apart from the existing ones in that it presents a comprehensive approach to assessing the effects of creating the gas industry in the region. According to this approach, first, both the level of development of the industry itself and its contribution to the regional economy are assessed; second, we analyze the entire array of projects already completed in the gas industry of the Russian Far East and those in progress; third, alternative configurations of the gas industry, combining the main stages of the gas processing chain are described; fourth, we assess the results of the industry development obtained to date, as well as prospective results expected in connection with the introduction of additional industry superstructures in the

form of production facility complexes of gas processing and gas chemistry.

III. RESEARCH METHODS

In this paper we conduct a comprehensive analysis of major investment projects in the gas industry of the Russian Far East. As for the already implemented projects, we estimate their effects based on the shift-share analysis method. In this study we use a spatial version of the method proposed in [16], which is compatible with the classical version. On the basis of the three identities, we construct estimates of three pairs of industry and competitive effects, characterizing the standing of the gas industry of a particular region in the national, macro-regional, and local economies:

$$g_i = G + (G_i - G) + (g_i - G_i), \quad (1)$$

$$g_i = \hat{g} + (\hat{g}_i - \hat{g}) + (g_i - \hat{g}_i), \quad (2)$$

$$g_i = \hat{g} + (g_i - g) + (g - \hat{g}), \quad (3)$$

where G , \hat{g} , g are the growth rates of the national economy, the neighborhood economy of the region (the neighborhood includes regions sharing a border with the region in question) and the region's economy itself; G_i , \hat{g}_i , g_i are the growth rates of the gas industry in the national economy, in the economy of the neighborhood, and in the region's economy itself; $G_i - G$, $\hat{g}_i - \hat{g}$, $g_i - g$ are industry-mix effect, spatial industry-mix effect, and regional industry mix-effect, respectively; $g_i - G_i$, $g_i - \hat{g}_i$, $g - \hat{g}$ are competitive effect, spatial competitive effect (at the industry level), spatial competitive effect (at the level of the entire economy) effects, respectively.

Estimates of the structural shifts at the national level (identity (1)) indicate whether the task of advanced development of the gas industry in the Russian Far East has been completed. Estimates of the cross-regional (macro-regional) level (identity (2)) - indicate whether there was an increase in the degree of connectivity of the economic space of the Russian Far East. Estimates of the regional level (identity (3)) indicate whether the industry obtained the status of the «regional growth driver» and whether its degree of involvement in the structural links of the Russian Far Eastern economies has changed. The calculations use data on the average annual number of employees.

As for the projects that are currently underway, and this refers primarily to projects for the construction of gas processing and gas chemical complexes, their prospective effects are assessed in terms of the concept of iterative cross-industry modeling based on the multipliers of the input-output model. The input-output model is expanded by the inclusion in the base year model of information on technologies and products of gas processing. We assume 2015 as the baseline year, after which the investment phase for the gas processing project began. A social accounting matrix is constructed for 2015, which is then transformed as informed by the data on the production and investment program for the creation of gas processing and gas chemical

TABLE 1. Characteristics of the Natural Gas Resource Base in the Russian Far East

Metric	Sakhalin region	Republic of Sakha (Yakutia)	Kamchatka territory	Chukotka autonomous district
Number of hydrocarbon deposits, pcs.	63 onshore and 18 offshore deposits in the Sea of Okhotsk	40	4	2
Gas reserves*, bcm	1,524.7	2,971.4	7.8	9.4
Gas resources, bcm	236.5	10,796.9	693.2	283.9
Production volume in 2019, bcm	31.5	4.1	0.4	0.06
Production growth rate in 2012-2019, times	1.9	2.1	1.1	1.9

Source: Subsoil Use. Mineral and raw material base // Department of Subsoil Use in the Far Eastern Federal District <https://dvfo.rosnedra.gov.ru/page/425.html>

Note: * total reserves of categories A, B, C1, and C2.

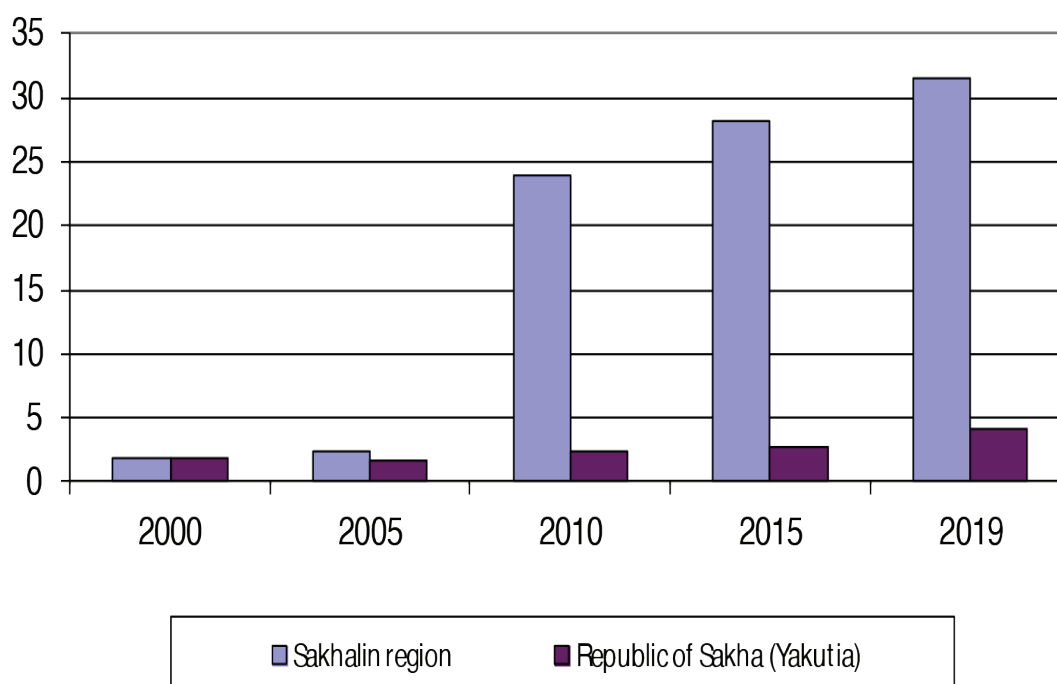


Fig. 1. Dynamics of natural gas production in the Republic of Sakha (Yakutia) and the Sakhalin Region, 2000-2019, bcm.

complexes in the region. For gas processing, we carry out additional calculations of economic effects based on the FrEEDM (Far Eastern Economic Dynamic Model) model of economic interactions described in [17].

IV. GAS INDUSTRY IN THE RUSSIAN FAR EAST: MAJOR INVESTMENT PROJECTS OF THE 2000S.

Recoverable oil and gas reserves have been discovered in the Sakhalin region (including the shelf of the Sea of Okhotsk), Kamchatka territory, Chukotka autonomous district, Khabarovsk territory, and the Republic of Sakha (Yakutia). The Russian Far East accounts for about 7% in the stock of Russian gas reserves and about 6% in the stock of unproven reserves. The region is characterized

by a low degree of exploration (21%) and a low degree of reserve depletion (6%). Both of the indicators attest to the high potential of new large deposits and the prospects for increasing production in the region.

For a long time, the rich resource base of the Russian Far East remained unsolicited with respect to natural gas resources. We can highlight the following factors that hinder the development of the industry: low capacity of intraregional demand (the demand is 5-7 times lower than the potential production volume), limited scope of geological studies of the area, lack of necessary transport infrastructure, high costs of production and transport, multi-component composition of natural gas in the Republic of Sakha (Yakutia).

TABLE 2. Trunk Gas Transport Systems in the Russian Far East

CHARACTERISTIC	Sakhalin		Kamchatka	Sakha
	Trans-Sakhalin pipeline system	Sakhalin – Khabarovsk – Vladivostok	Sobolevo – Petropavlovsk-Kamchatsky	The Power of Siberia
Year of commissioning	2008	2011	2010	2019 (Stage 1)
Throughput capacity, bcm	15	5.5	0.75	61, inclusive of the following 38 (exports)
Length, km	800	1 800	392	3 200
Resource base	offshore fields in the Sea of Okhotsk	fields of the Sakhalin island and the shelf deposits of the Sea of Okhotsk consumers in Khabarovsk territory, Primorsky	Kshuuskoye GCF, Nizhne-Kvakchikskoye GCF	Chayandinskoye OGCF, Kovyktinskoye GCF
Consumers	LNG plant (exports to APAC countries)	territory, and Sakhalin region; prospective exports to APAC countries	energy facilities of the Kamchatka region	Amur GPP, exports to China

TABLE 3. Gas Processing Plants in the Russian Far East

CHARACTERISTIC	Sakhalin Gas Production Center		Yakutsk Gas Production Center	
	Sakhalin LNG plant	Yakutsk GPP	Amur GPP	Amur GCC
Year of commissioning	2009	1999	2021 (2 process lines)	(2020 - start of construction)
Design capacity	10.4 million tons	40 thousand tons	42 billion cubic meters of natural gas per year	2.7 million tons
Products	LNG	methane, LPG, gasoline, propane-butane	helium, ethane, propane, butane, pentane-hexane fraction	polyethylene, polypropylene
Resource base	Sakhalin-1 and Sakhalin-2 project fields	Srednevelyuiskoye GCF and Mastakh GCF	Chayandinskoye OGCF, Kovyktinskoye GCF	ethane, methane, propane, and butane of the Amur GPP
Consumers	exports to APAC countries	Yakutskaya SDPP, domestic consumers within the republic	regional consumers, exports	regional consumers, exports

Source: compiled by the authors based on Golubeva I.A., Rodina E.V. Yakutsk gas processing plant (Sakhatransneftegaz JSC) // *Neftepererabotka i nefrekhimiya*. 2017. No. 4. Pp. 37-40; Yakutsk gas processing plant // Sakhatransneftegaz JSC, URL: <http://aostng.ru/about/structure/47/> (access date: 04.07.2022); Amur gas processing plant // Gazprom PJSC, URL: <https://www.gazprom.ru/projects/amur-gpp/> (access date: 04.07.2022); Amur gas chemical complex (AGCC), URL: <https://amur-gcc.ru/?ysclid=17k9jstqm513234110> (access date: 04.07.2022).

The development of the region's gas industry required large capital investment outlays and access to state-of-the-art technology, as well as a guaranteed demand volume, which, in general, only international cooperation provides. With this in mind, the Eastern Gas Program (hereinafter referred to as the Program) was adopted in 2007, combining gas production, transport, and processing projects in the Russian Far East and Eastern Siberia. The program is aimed at achieving two main goals: accelerated development of the eastern regions of the country on the basis of natural gas resources and consolidation and expansion of the niche of Russian gas in APAC markets. The program is divided into several stages, covering the time period to 2030. As part of the program, it was planned

to create three gas production centers in the Russian Far East: Sakhalin, Yakutia, and Kamchatka.

Gas is currently produced in four subjects of the Russian Federation located in the Russian Far East. Two main gas production centers have been formed in the region: the Republic of Sakha (Yakutia) and the Sakhalin region, which account for about 98% of free gas reserves (Table 1).

The dynamics of gas production in the region over the past two decades were mainly determined by the development of the Sakhalin center, primarily by the commissioning of the LNG plant in 2009, which provided the necessary infrastructure for gas exports (Fig. 1).

The increase in gas production in the Republic of

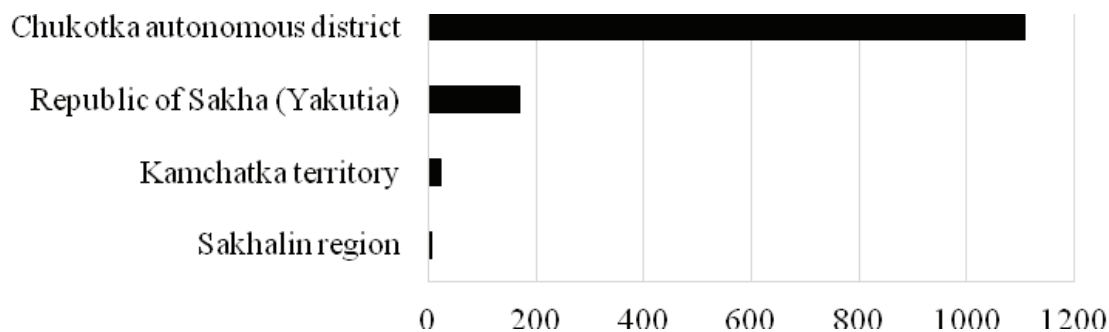


Fig. 2. Competitive effects in the gas industry of the Russian Far East in 2012-2019, %.

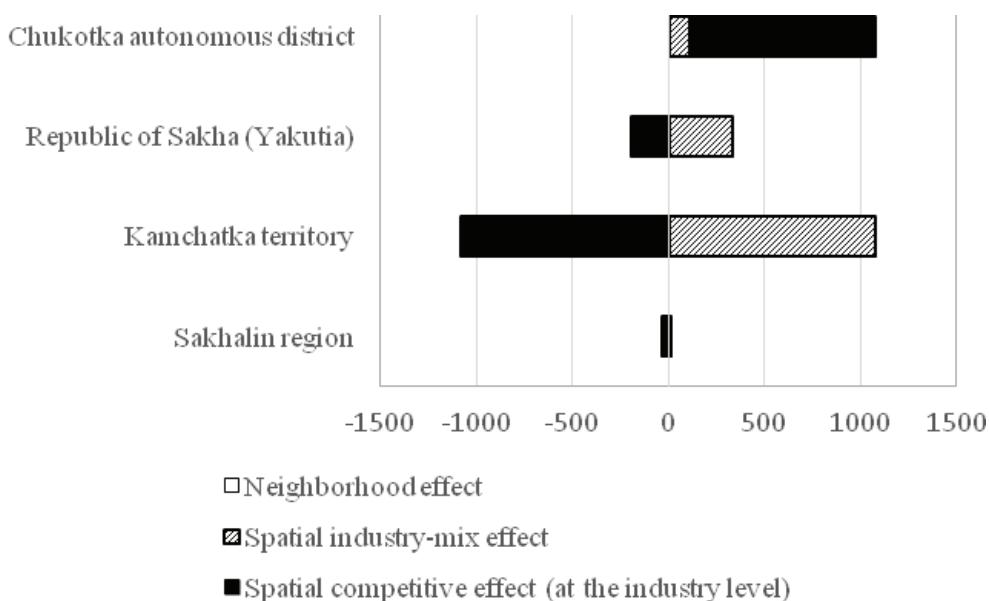


Fig. 3. Estimates of structural shifts in the gas industry of the Russian Far East in 2012–2019 (cross-regional/macro-regional level), %.

Sakha (Yakutia) in 2008-2019 was due to the increase in associated gas extraction as oil production increased and the «Eastern Siberia - Pacific Ocean» oil pipeline was commissioned. Starting from 2019, the growth of gas production in the republic was caused by fulfillment of obligations under the long-term project of gas supplies to China and commissioning of the Power of Siberia GTS.

Gas producers in the Chukotka autonomous district and Kamchatka territory focus exclusively on meeting the demand of domestic consumers. At the same time, there is a shortage of resources in the Kamchatka center.

There is no unified gas supply system in the Russian Far East. To date, only separate local gas transport systems have been created: 1) gas supply pipelines for gasification of individual settlements and industrial enterprises

«Zapadno-Ozernoye GCF - Anadyr» in the Chukotka autonomous district; 2) four local gas transport systems operating in a closed and technologically independent manner in the Republic of Sakha (Yakutia), such as «Kyzyl-Syr - Mastakh - Berge - Yakutsk» and «Mirny - Aikhal - Udachny»; 3) the trunk gas transmission system of the Kamchatka gas production center («Sobolevo - Petropavlovsk-Kamchatsky»); 4) trunk gas transmission systems of the Sakhalin gas production center: «Sakhalin - Khabarovsk - Vladivostok» and Trans-Sakhalin pipeline system, 5) trunk gas transmission system of the Yakutsk gas production center «Power of Siberia» Stage 1 (Table 2).

The underdeveloped transport infrastructure still restricts the development of the gas industry in the Russian Far East, including delays in the commissioning of gas

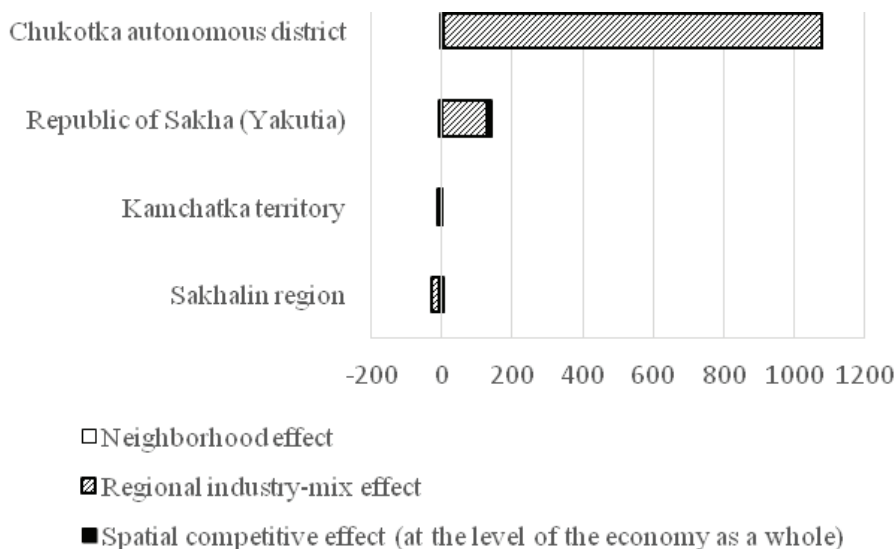


Fig. 4. Estimates of structural shifts in the gas industry of the Russian Far East in 2012-2019 (regional level), %.

processing facilities and the implementation of the region’s gasification program.

Between 2012 and 2019, the bulk of projects in the gas industry related to development of the resource and transport infrastructure were implemented, but projects in the gas processing segment as of 2022 are still at various stages of construction.

The gas processing industry in the eastern regions is represented by two operating plants: the Yakutsk gas processing plant and the Sakhalin liquefied natural gas (LNG) plant, as well as two interconnected plants that are currently under construction: the Amur Gas Processing Plant and the Amur Gas Chemical Complex (Table 3). The gas processing facilities (Amur Gas Processing Plant and Amur Gas Chemical Complex) are scheduled to reach their design capacity in 2024-2025.

Yakutsk GPP products are consumed within the Republic of Sakha (Yakutia), while all LNG products from the Sakhalin LNG plant are exported under long-term contracts. The main purpose of the Amur GPP is to extract important components from natural gas. The plant is an important link in the process of supplying natural gas to China via the Power of Siberia gas transmission system. The plant’s products are intended both for the domestic market and for the global market (helium and sales gas (methane)). The Amur Gas Chemical Complex (a joint project of SIBUR and Sinopec) is envisioned as the main consumer of the Amur GPP products (ethane and LPG), while the plant itself is focused on the markets of APAC countries, primarily China.

In general, it can be noted that the development of the gas industry in the Russian Far East in the first two decades followed a trajectory of extensive growth. Priority was given to projects of expanding the resource base and building transport infrastructure, which was subordinate to the goal of increasing natural gas exports to APAC countries. At the same time, the region is still characterized by a high potential for increasing physical volumes of natural gas exports.

V. RESEARCH FINDINGS

VI. Estimates of structural shifts in the gas industry in the Russian Far East

Since the main projects to develop the resource base and transport infrastructure in the Russian Far Eastern gas industry were completed by 2012, the calculations used data on the average annual number of employees from 2012 to 2019. During the period under review, employment in the gas industry of the Russian Far East increased by 24.0%. Estimates of structural shifts obtained at the national level confirm the special status of the gas industry of the Russian Far East in the national economy. Competitive effects in this case (60.5%) are not only positive but also dominate in relation to the national (-4.4%) and industry-mix (-32.1%) effects.

The spatial structure of the competitive effects is presented in Figure 2 (regions are ordered here from top to bottom in descending order of the growth rate of employment in the extractive industries).

The projected spatial distribution of economic activity within the gas industry generally coincides with the actual one. The variation in the values of competitive effects depends on the degree of completion of projects in different regions of the Russian Far East. For example, the high value of the growth rate of the average annual number of employees in the gas industry obtained for the Chukotka autonomous district is nothing but the effect of a low baseline. As stated above, the natural gas extracted in the district is used exclusively for domestic needs. Until 2017, the volume of gas production and consumption in the region was insignificant (about 30 million m³), but, starting from 2018, it increased due to the launch of the coal-to-gas switching of the Anadyrskaya CHPP.

Estimates of structural shifts obtained for the gas industry of the Russian Far East at the cross-regional and regional levels are shown in Figs. 3 and 4.

Positive values of spatial industry-mix effects in the regions of the Russian Far East indicate the complementarity of projects in the gas industry. In the case of the Kamchatka territory and Chukotka autonomous district, this also indicates a certain increase in the degree of space connectivity due to the implementation of gasification programs. Nevertheless, we cannot speak about the realization of the potential for generating spatial externalities in this case, because for all regions of the Russian Far East (with the exception of the Chukotka autonomous district) the spatial industry-mix effect and spatial competitive effect have different signs. Negative values of spatial competitive effects indicate that the regions of the Russian Far East lose out in cross-regional competition (primarily to the regions of Siberia).

In accordance with the results of the analysis of structural shifts at the regional level, the dynamics of the gas industry are almost unaffected by the overall competitiveness of regional economies (the overall spatial competitive effects in this case are very low). As a rule, the gas industry develops faster than others (the exception here is the gas industry of the Sakhalin region, which is inferior in terms of development rates, primarily to the region's oil industry), while remaining a kind of enclave in the economies of the regions.

Thus, the scale of support for the gas industry in the Russian Far East was sufficient to produce positive and significant competitive effects in it, overriding the impact of negative shocks that destabilize the national economy. But how these incentives will «work» in the future largely depends on the nature of structural links within the gas processing and gas chemical industry, which is new for the region, the results of the creation of which in the period under review remained imperceptible.

VII. Assessment of prospective economic effects of creating a gas processing and gas chemical complex in the Russian Far East

The gas processing and gas chemical industries are new to the Russian Far East and change the established system

of economic relations, primarily within the energy sector itself. In general, the process flow of obtaining products of the industry is as follows: energy resource (Stage 1) → primary processing products (Stage 2) → basic monomers (Stage 3) → polymers (Stage 4). Accordingly, it is expedient to assess the economic effects of creating the gas industry under two scenarios: the first scenario assumes the gas industry, combining 1 and 2 stages of the process flow; the second scenario - the industry, combining 1 to 4 stages of the process flow. The core of the new industry is formed by the Amur Gas Processing Plant and the Amur Gas Chemical Complex. The Amur Gas Chemical Complex is supposed to produce basic monomers and polymers, with monomers as intermediate products that are used within the production process.

The emergence of gas processing and gas chemistry in the economy of the Russian Far East will boost the demand for products and services of the existing industries in the region, including capital asset-forming industries, but will not entail changes in the structure of their costs. According to balance estimates, the emergence of gas processing in the region's economy will increase the GRP by 11.2% compared to 2015, and the emergence of gas processing and gas chemistry will provide a total increase in the GRP by 13.9%. The largest increases in gross output are planned in the gas production, oil refining, and electric power industries. At the same time, the capacity reserves of the industries supplying resources for the new complex of industries are sufficient to ensure the above growth of the GRP of the Russian Far East.

According to the results of calculations based on the FrEEDM model, provided that all production lines of the Amur GPP are put into operation, the above increase in the GRP can be achieved by 2030. The effects of the creation of gas processing are already expected during the investment phase. At the same time, due to the reproduction structure of capital investment, it will be impossible to claim the adequate transformation of this investment into growth rates of regional aggregated performance indicators; by 2030 the value of the investment multiplier will not exceed unity.

The products of the gas-processing complex will essentially match the low degrees of processing and will be exported, as a result of which the effects of the operational phase, produced by technological changes, are almost twice as low as the effects of the investment phase.

VIII. DISCUSSION

The research findings presented in this paper are consistent with the results of other studies with respect to confirming the low efficiency of energy projects from the standpoint of stimulating regional economic dynamics [6; 11; 12; 18; 19].

Despite the spatial complementarity of gas production projects, calculations have provided no evidence for the existence of spatial externalities in the gas industry of the

Russian Far East. The losing out of the Russian Far East regions in cross-regional competition to Siberian regions observed by the authors aligns well with the results obtained by the experts of the Higher School of Economics in their analysis of the economic specialization of the regions [20]. According to NIU HSE estimates, for Sakhalin region and the Republic of Sakha (Yakutia. For the republic, in addition to the local importance, we also noted the importance of the industry on a national scale.) production and transport of hydrocarbons are of local importance, for the Kamchatka territory and Chukotka autonomous district they are not industries of their specialization, while for the Irkutsk region and Krasnoyarsk territory they are industries of specialization of national importance.

IX. CONCLUSION

The scale of support for the gas industry in the Russian Far East was sufficient to produce positive and significant competition effects in it, overriding the impact of negative shocks that destabilize the national economy. In the structure of the economies of the Russian Far East regions, the gas industry tends to develop at a faster pace than other industries, while remaining a kind of enclave.

Projects to develop gas processing and the establishment of the gas chemical industry are associated with a steady increase in the GRP of the Russian Far East, but the investment multipliers of these projects by 2030 fail to reach unity. Due to the fact that the products of the gas-processing complex will correspond to low degrees of processing and will be exported, the extent of close economic interactions does not change much within the economic space of the Russian Far East, .

Thus, the accelerated development of the gas industry in the considered configurations (without/with processing facilities) in general does not translate into the development of the Russian Far Eastern economy itself. Our analysis showed that the projects currently being implemented in the region's gas industry are subordinate to the objectives of the national economy and do not solve the problem of forming a unified economic space in the Russian Far East that would be characterized by the closeness of economic interactions.

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