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Major Financial and Economic Trends in the Development of the Petrochemical Complex in the Republic of Tatarstan

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Abstract

This article analyses the main economic indicators of the petrochemical complex manufacturing technology chain in the Republic of Tatarstan, which includes the following vertically integrated types of economic activities: extraction of mineral resources; oil refining; chemical production; rubber and plastic products manufacturing. The authors carried out a simple linear regression analysis of the manufacturing technology chain development in the petrochemical complex of the Tatarstan Republic. The article describes the approach that allows investigating mutual factors trends of labor and capital at different levels of the manufacturing technology chain in the petrochemical complex of the regional economy in the Republic of Tatarstan. The authors come to the conclusion that the functioning of the manufacturing technology chain is the more efficient the more elastic the effect of the chain lower level on the development of the corresponding upper level.

Keywords: petrochemical complex, oil extraction, oil refining, chemical production, rubber and plastic products manufacturing, manufacturing technology chain.

I. INTRODUCTION

The petrochemical complex is a key sector of the regional economy in the Republic of Tatarstan, providing maximum volumes of added value, filling the budget of the region; its progressive development provides solutions to a wide range of social problems.

Such major budget revenue generating enterprises and employers in the Republic of Tatarstan as PJSC TATNEFT, TAIF-NK PSC, PJSC "Nizhnekamskneftekhim", Kazanorgsintez PJSC, JSC Nefis Cosmetics, a group of companies of the tire-manufacturing complex of PJSC TATNEFT provide about 90% of the sales volume of the main companies in the petrochemical complex. These enterprises belong to the largest companies in Russia and Europe (for certain types of products).

In 2019 the total volume of oil extraction in the Republic of Tatarstan was 36.6 million tons, the total volume of PJSC TATNEFT was 29.5 million tons of oil. Within the reporting period 18.6 million tons of hydrocarbon raw materials were processed at refineries in the Republic of Tatarstan. The industry has increased the production of motor gasoline (by 2.4 times), diesel oil (by 23.5%), petroleum oils, heavy distillates (not included in other groups) (by 16.2%), fuel oil (by 3.2%) [2].

In order to increase the refining depth and the yield of light oil products, TAIF-NK PSC and JSC TANECO are implementing major investment projects. TAIF-NK PSC is completing the construction of the complex for advanced refining of heavy residues of the oil refinery plant. On a scheduled basis PJSC TATNEFT is constructing the Complex of Refining and Petrochemical Plants in Nizhnekamsk (JSC TANECO) with the range expansion of produced oil products and improvement of their quality.

On February 12, 2019, President of the Russian Federation V.V. Putin and President of the Republic of Tatarstan R.N. Minnikhanov launched the production of gasoline at the Nizhnekamsk oil refinery complex of TATNEFT − TANECO. Shipment of high-quality commodity gasolines of AI-92, AI-95, AI-98, AI-100 brands with the best operational and ecological characteristics is begun at full capacity. The design capacity of motor gasoline production is more than 1.1 million tons per year. Every day it is planned to produce up to 3000 tons of quality fuel.

In 2019 the second primary oil processing plant was launched at JSC TANECO. The estimated output of the CDU-VDU-6 plant is 6 million tons of crude oil per year with its start-up the total design capacity of JSC TANECO for primary oil refining increases to 15.3 million tons per year.

In comparison with the previous year, chemical production, rubber and plastic products manufacturing, production of medicines and materials increased production of benzene (by 23.4%), synthetic detergents (by 11.1%), plastic in primary forms (by 1.9%), paints and varnishes (by 3.9%), decreased production of glycerin (by 23.1%), technical carbon (by 16.2%), and synthetic rubber (by 6.4%) [1]. The average number of employees in chemistry enterprises is 31.5 thousand people.

The industry has an increase in the production of plastic pipes, hose pipes, fittings (by 9.5%), window plastic blocks (by 17.8%) and a decrease in the production of tires (by 29.8%).

In February 2019, Oligomer Plant of PJSC "Nizhnekamskneftekhim" launched a new production of catalyst KDI-M with a capacity of 3 thousand tons per year.

Its construction was started in 2016 as part of an investment project to increase the production of isoprene rubber SKI-3 to 330 thousand tons year. Commissioning and start-up operations at production began at the end of January. The first batch of catalysts was obtained on February 14. The micro spherical chromic-alumina dehydrogenation catalyst of KDI-M grade is used for synthesis of isobutylene by dehydrogenation of isobutane and isoamylenes by dehydrogenation of isopentane. Nizhnekamsk KDI-M is characterized by increased activity and selectivity, it provides more stable yield of the product.

According to the industry-based aspect of the petrochemical complex the following new industries were opened on the territory of the Special Economic Zone "Alabuga" in 2019:

- Plant for chemical crop protection products LLC "August-Alabuga". The design capacity of production will be more than 50 million per year;

- Plant for production of one-component polyurethane assembly foams LLC "TN- Alabuga";

- Plant for manufacturing drag reducing agents LLC "Transneft Synthesis". Production is designed for annual output of up to 3 thousand tons of drag reducing agent additives taking into account the possibility of increasing the capacity to 10 thousand tons per year.

II. MATERIALS AND METHODS

The research describes basic indicators of the following vertically integrated economic activities of the manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan:

- Extraction of mineral resources;

- Oil refining;

- Chemical production;

- Rubber and plastic products manufacturing.

The research includes a simple linear regression analysis of the manufacturing technology chain development in the petrochemical complex of the Republic of Tatarstan to assess the effectiveness of formation and development. The authors introduce their own approach to investigate trends of mutual factors of labor and capital at different levels of the manufacturing technology chain in the petrochemical complex of the regional economy in the Republic of Tatarstan.

III. RESULTS AND DISCUSSION

III.I Industrial production index

The basic indicator showing the intensity of the development of enterprises, industries and complexes is the industrial production (volume) index (IPI). It's necessary to study the dynamics of this indicator in the industries forming the manufacturing technology chain of the petrochemical complex in the Republic of Tatarstan.

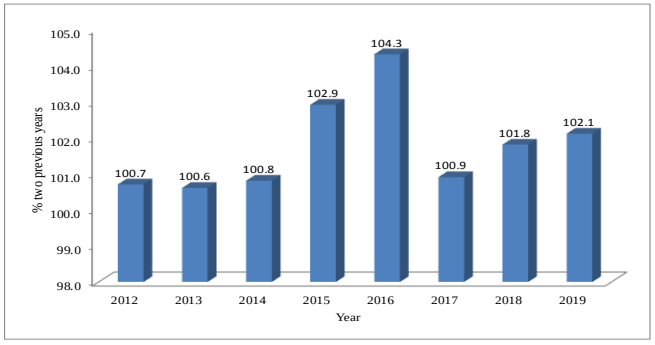

Figure 1. Dynamics of IPI in the extraction of mineral resources in the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan)

As shown in figure 1 in 2012-2019 it is possible to distinguish several cyclical fluctuations in the development of the extraction industry in the petrochemical complex of the Republic of Tatarstan according to IPI:

- Inertial change of IPI in 2012-2014;

- Intensive growth of IPI in 2014-2016 (local maximum dynamics of the considered indicator was achieved in 2016 − 104.3%) due to a number of interrelated factors, such as development intensity in a number of new deposits, active use of innovative technologies to increase reservoir recovery, as well as the impact of the so-called compensatory effect on the oil extraction (objective aim of oil companies to increase oil and associated natural gas extraction under not quite positive conditions in the world energy market; thus, the average annual price of a barrel of Brent oil was 112.4 dollars in 2013, and it was only 57.3 dollars in 2016);

- Transition to a new less intensive stage of the industry cycle, characterized by variability of IPI at the level of 100.9% to 102.1% to the level of the previous period in 2017-2019.

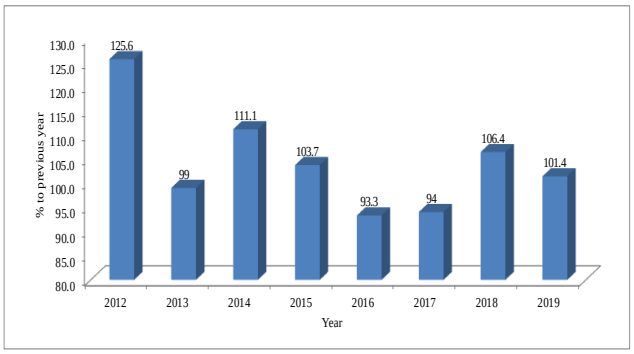

Figure 2. Dynamics of IPI in oil refining in the Republic of Tatarstan

As shown in figure 2 the development of the oil refining industry in the Republic of Tatarstan is characterized by a significantly higher level of volatility of IPI in 2012-2019. The local maximum of this trend (125.6%) was reached in 2012 due to the introduction of a number of new capacities of

JSC TANECO. At the same time there was a 1.0% reduction of IPI in 2013.

The least effective development of this industry was in 2016-2017, when the annual volume of production decreased by 6-7%, which was extremely significant. The main reason for the decline was the negative conditions of both the world and national oil refining markets. At the same time, the period of 2018-2019 can be characterized as a phase of inertial recovery growth for this sector of the petrochemical complex.

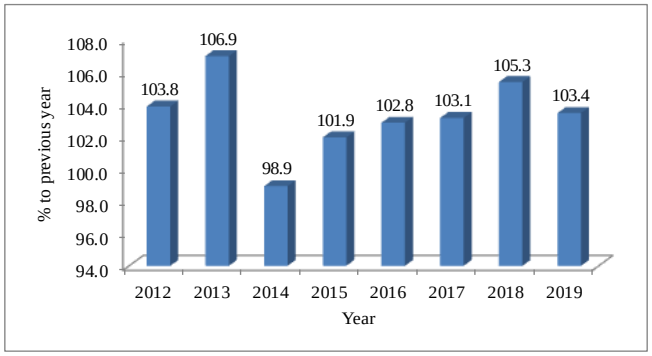

Figure 3. Dynamics of IPI in the chemical production in the Republic of Tatarstan

As shown in figure 3 the chemical production of the petrochemical complex is also characterized by a significant development cycle. Thus, the growth of IPI in 2012-2013 to a local maximum of 106.9% was largely due to the effect of the industry recovery the after the world financial and economic crisis of 2007-2010, intensive development of chemical products industrial markets in this period. In addition, in 2012-2013 there was an increase in export potential of chemical industry enterprises of the Republic of Tatarstan, primarily in terms of development of the corresponding industrial markets of the EAEU and BRICS.

In 2014 there was a 1.1% decrease in IPI in chemical production of Tatarstan. It was due to the processes of corporate restructuring in a number of industrial enterprises, under the conditions of reorganization the volume of production usually decreases due to the increasing uncertainty of the management decision-making processes, implementation in such conditions of a mainly conservative strategy of financial and economic development and production.

The period of 2015-2018 was characterized by a steady increase in the indicator of IPI in chemical production of the regional economy in the Republic of Tatarstan from 101.9% to 105.3%, respectively. One of the growth main factors was the steady devaluation of the national currency, which determined the reduction of competitiveness of imported chemical products in the national industrial market. It is not quite clear whether some reduction in chemical production in the Republic of Tatarstan in 2019 can be considered as a long-term trend of industry recession or depression.

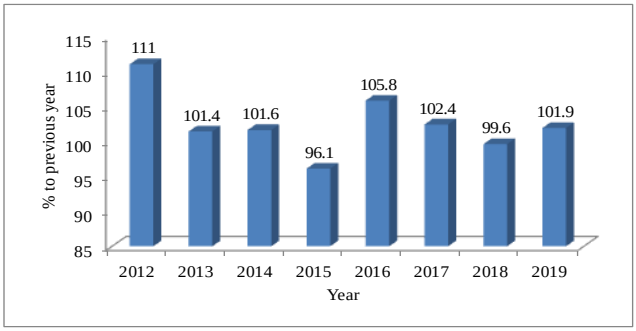

Figure 4. Dynamics of IPI in rubber and plastic products manufacturing in the Republic of Tatarstan

As shown in figure 4, the rubber and plastic products manufacturing of the regional economy in the Republic of Tatarstan is characterized by two downturns in cycles: 2012-2015 and 2016-2018. In general, according to the IPI, the development of this element of the manufacturing technology chain of the petrochemical complex in the Republic of Tatarstan is the least stable. It is due to the high level of competition in the national industrial market, as well as the lack of stability of consumer demand, in particular in the segment of the key industrial products such as tires.

III.II Shipping volume of products

The dynamics of the indicator of the shipping volume of products in value terms (Table 1) underlines the intensity of the development of manufacturing technology chain levels in the petrochemical complex of the Republic of Tatarstan. This indicator, unlike the IPI, also takes into account the influence of the industry price factor.

Table 1. Dynamics of shipping volume of products within the manufacturing technology chain levels in the petrochemical complex of the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan)

Years	Oil Extraction	Oil Refining	Chemical Production	Rubber and Plastic Products Manufacturing
2012	348938,5	239104,6	211528,0	65431,3
2013	360137,7	264914,3	209704,8	61421,4

2014	365332,7	314677,7	229191,8	63254,9
2015	434290,8	357379,6	258372,5	81272,9
2016	439147	347551,9	278648,6	84373,3
2017	469922,6	386519,9	285406	88898,3
2018	617550,2	616460,3	332877,2	105124,9
2019	1019800	778000	248700	92600
Growth rate, 2019 to 2012, %	292,3	325,4	117,6	141,5

As shown in table 1, the largest growth rate of the shipping volume of products in 2012-2019 occurred within such level of the manufacturing technology chain in the petrochemical complex as oil refining (325.4%). Substantially such intensive growth was caused by the action of an industrial price factor: for the studied period retail prices for gasoline (the main product of oil processing) increased in the regional economy of Tatarstan by 2.72 times [3] that is significantly higher than the general rate of inflation in the economy.

In 2012-2019 quite substantial shipping volume of products in oil extraction (292.3%) was due to a set of the following main factors:

- Certain recovery of oil market prices in 2016-2019 after sharp drop of this indicator in 2014-2015;

- PJSC TATNEFT consistent policy of volume increase in oil extraction provided by the system of strategic development plans of the company;

- Efficient operations of the enterprise sales service;

- Balanced structure of oil sales in domestic and foreign markets.

The lowest growth rate of the shipping volume of products in the group of investigated levels of the manufacturing technology chain in the petrochemical complex was in the regional chemical production industry (117.6%) in 2012-2019. In fact, there was a decrease in the shipping volume during the period under review. In our opinion, this indicates a lack of efficiency in the organization and implementation of sales and marketing activities in many enterprises of this sector of the petrochemical complex in the regional economy of the Republic of Tatarstan, which produce quite competitive products.

III.III Product profitability

One of the most significant indicators of efficiency in financial and economic activity of enterprises and industries is product profitability. Values of this indicator for the levels of the considered manufacturing technology chain are given in figure 5.

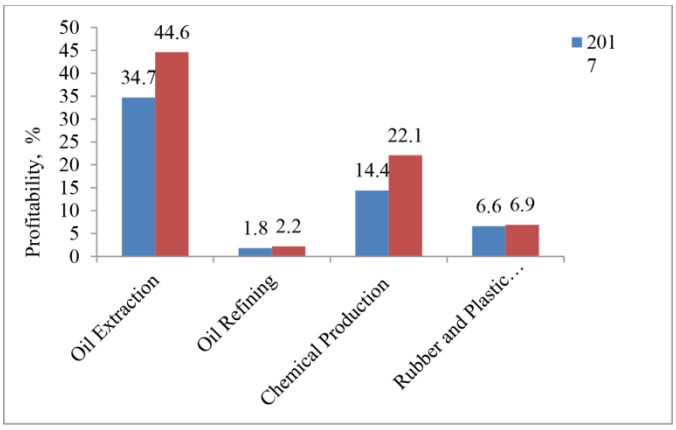

Figure 5. Average level of product profitability in the sectors of the manufacturing technology chain in the petrochemical complex in the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), %

As shown in figure 5, the product profitability in the industries forming the manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan differentiated extremely significantly in 2017-2018. The profitability level in oil extraction was very high (44.6%) in 2018, significantly exceeds average values of this indicator in oil extraction of the USA and countries of the EU (on average 17-20% [4]. In fact, this indicates that there is a rather effective and balanced system for managing the costs and financial results of the activities of PJSC TATNEFT.

At the same time, a significant threat to progressive development of the manufacturing technology chain in the petrochemical complex is posed by extremely low level of average product profitability in the regional industry of oil refining (2.2% following the results of 2018 that more than twice there is less value of a similar indicator on the field of oil refining in the Russian Federation in general (4.7% in 2018 [5])). In fact, there is a different trend of economic development of this level of manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan: intensive growth of the shipping volume is accompanied by

the presence of extremely low level of profitability.

The authors consider that the main reasons for the unsatisfactory level of average profitability in oil refining in the regional economy of the Republic of Tatarstan are:

a) Implementation of a large-scale investment program for the development of the oil production industry in the Republic of Tatarstan, primarily intensive investments in the process of reproduction of high-tech fixed assets of JSC TANECO in 2013-2018, eventually led to a significant increase in the amounts of depreciation contributions (at the same time, depreciation charges have a positive impact on the volume of value added and the generation of net cash flow in the industry, but lead to a decrease in the level of operating profit and profitability of the products);

b) Presence of relatively large general and administrative expenses and transaction costs of activity in oil refining of the regional economy in the Republic of Tatarstan;

In general, in the medium term, the possible maintaining of an extremely low level of profitability in oil refining may lead to the following negative consequences of the development at this level of the manufacturing technology chain in the regional petrochemical complex:
- Increasing the probability of decreasing the solvency of enterprises in the sphere of regional oil refining, including in terms of financial arrangement with the initial level of the chain (PJSC TATNEFT) for the supplied raw materials, reducing the level of financial stability of the activity of this level of the production and technological chain as a whole;
- Reduction of the possibility to attract JSC TANECO bank credit resources due to the fact that the difference between the average interest rate on loans for organizations and the level of product profitability in 2019 exceeded five times;
- Main difficulties for JSC TANECO in the organization and implementation of prospective possible IPO on the national or international stock market due to the fact that the level of product profitability is one of the basic criteria of investment attractiveness of the issuer, to which any types of potential buyers of shares or corporate bonds (from strategic investors to stock speculators) pay attention.

As a positive fact, the level of average profitability in regional chemical production is quite high (22.1%). At the same time there was a steady decrease in the shipping volume in the companies of this industry in the regional economy in 2018-2019. A comparison of the two trends suggests that most parts of the profit generated by the chemical industry in Tatarstan is directed towards current consumption rather than investment development, which ultimately increases the volume of commercial output.

The average level of profitability within the upper level of the manufacturing technology chain in the petrochemical complex − rubber and plastic products manufacturing (6.9% according to the results of 2018) is comparable to the average Russian industry level of this indicator, but it is still insufficient to ensure extended reproduction of organizations in this type of economic activity in the regional economy.

III.IV Residual value of fixed assets

In general the basic factor of production of capital-intensive sectors of the petrochemical complex is fixed assets. Dynamics of residual value of fixed assets in industries forming the investigated production and technological chain is given in table 2.

Table 2. Residual value of fixed assets in industries forming the investigated manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), mln RUB

Years	Oil Extraction	Oil Refining	Chemical Production	Rubber and Plastic Products Manufacturing
2012	186126,8	92685,67	91948,74	16264,06
2013	206807,5	102984,1	102165,3	18071,18
2014	229786,1	114426,8	113517	20079,09
2015	255317,9	127140,8	126130	22310,1
2016	283686,6	141267,6	140144,4	24789
2017	324469,7	205521,2	144697,8	25903,08
2018	358258,3	211279,1	164379,2	27941,94
Growth rate, 2018 to 2012, %	192,4	227,9	178,7	171,8

According to the data in table 2 the most intensive processes of fixed capital reproduction were in the regional oil refining in 2012-2018. At the same time in the conditions of the previously considered deficit of profitability in this industry, the main sources of expansion of fixed assets of companies in this industry were funds of shareholders, including the budget of the Republic of Tatarstan.

III.V Labour force

Another important factor in ensuring the efficiency of production activities of the manufacturing technology chain industries in the petrochemical complex of the Republic of Tatarstan is the labour force. The dynamics of the average number of personnel corresponding to the level of the development chain of the regional petrochemical complex is presented in table 3.

Table 3. Average number of industrial personnel of the manufacturing technology chain sectors of the petrochemical complex in the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), people

Years	Oil Extraction	Oil Refining	Chemical Production	Rubber and Plastic Products Manufacturing
2012	32407	6223	33821	15621
2013	32200	6309	33754	16472
2014	32389	6784	33100	15734
2015	32906	7300	33263	15521
2016	32502	7813	33800	13478
2017	35239	9905	32779	15409
2018	32892	8387	31760	14570
Growth rate, 2018 to 2012, %	101,4	134,7	93,9	93,2

As shown in table 3, the period of 2012-2018 was characterized by an intensive increase in the average number of industrial personnel within the group of industries under consideration only for the oil refining. Such a rather rapid growth of labour force, especially for the period of 2016-2017, was due to the expansion of the volume of production capacities of JSC TANECO, the introduction of new workshops at this industrial enterprise.

However, as shown by the comparison of time series in table 1 and table 3, the growth rate in the shipping volume of products in oil refining significantly exceeded the growth rate in the number of industrial personnel over the same period. It indicates a positive trend in productivity growth in the regional economy.

The regional oil extraction industry was characterized by an inertial increase in the number of industrial personnel by 1.4% in 2012-2018. At the same time during this period there were certain structural changes in the use of labour potential in the activities of PJSC TATNEFT. Thus, due to the intensification of the processes of automation and computerization of labor, there was a slight decrease in the number of direct and indirect personnel (by 4.2% in 2012-2018). At the same time, there was an increase in the number of the following categories of employees in the oil extraction industry of the Republic of Tatarstan:

- Increase of IT specialists of PJSC TATNEFT by 2.52 times in 2012-2018;

- Increase in the number of employees involved in R & D of different directions;

- Increase in the number of personnel of PJSC TATNEFT involved in a number of socially significant projects formed and implemented by the company, in particular within the system of its four charitable foundations.

As for the upper levels of the manufacturing technology chain in the petrochemical complex (chemical production and rubber and plastic products manufacturing) in 2012-2018 there was a consistent policy of optimization in the number of industrial personnel (the decrease of this indicator was 6.1% and 6.8%, respectively).

III.VI Level of average accrued salary

One of the main indicators of social efficiency of development in the manufacturing technology chain levels is the level of average accrued salary. Its level, compared to the average salary for the country and the region, determines the dynamics of productivity and efficiency of industrial development as a whole.

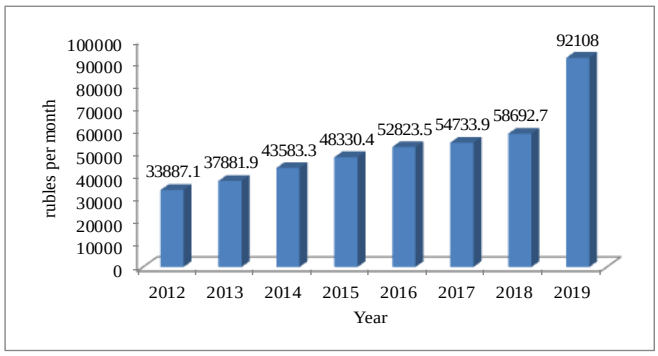

Figure 6. Dynamics of average monthly salary level in oil extraction in the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), rubles

As shown in Fig. 6, in 2012-2019 the average salary in oil extraction of the regional economy in the Republic of Tatarstan increased by 2.71 times in nominal terms. The high level of average salary, supported by the introduction of KPI, ensures a high degree of consolidation of industrial personnel in PJSC TATNEFT, stimulates a relatively low level of personnel turnover and, ultimately, creates conditions to achieve long-term sustainable productivity growth within this lower level of the manufacturing technology chain.

As shown in figure 7, the average salary in the oil refining in the regional economy of the Republic of Tatarstan amounted to 8,4086 rubles in 2019, exceeding the level of this indicator by 2.24 times in 2012. The increase in salary at the industrial enterprises steadily exceeds the level of officially registered inflation in the regional economy of the Republic of Tatarstan.

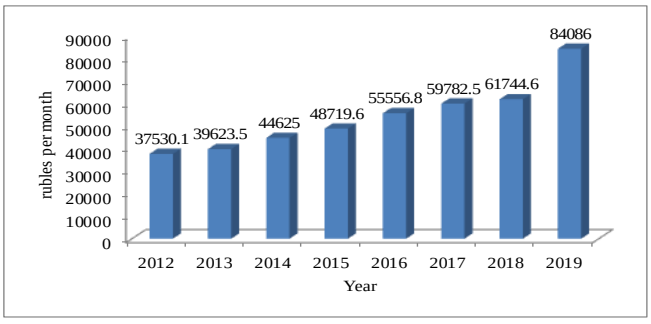

Figure 7. Dynamics of average monthly salary level in the oil refining of the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), rubles

As shown in figure 8, the chemical production of petrochemical complex is characterized by an sluggish growth in the level of average salary in 2012-2019. In 2019 it amounted to 53,467 rubles, which is 1.74 times higher than the level of the same indicator in 2012. According to the results of 2019, the average salary in the chemical production exceeded the value of the considered indicator for the regional economy in the Republic of Tatarstan as a whole by 26.1%.

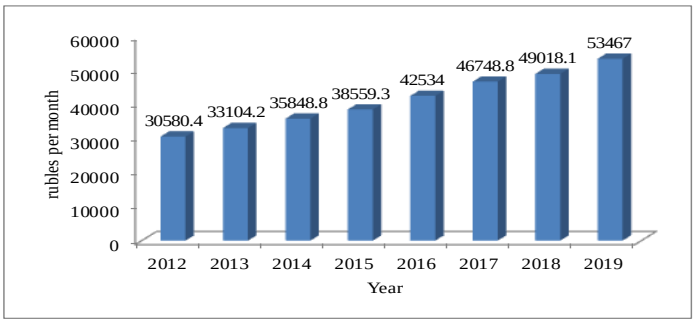

Figure 8. Dynamics of average monthly salary level in chemical production of the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), rubles

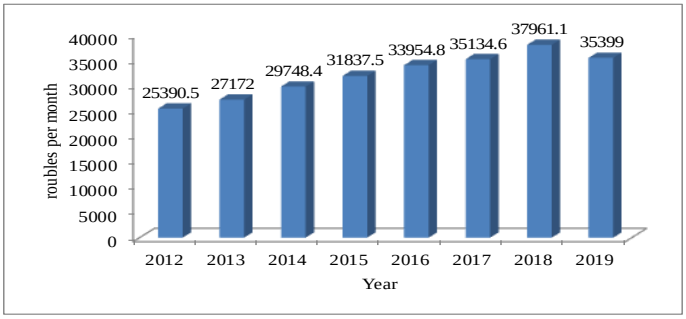

Figure 9. Dynamics of average monthly salary level in rubber and plastic products manufacturing of the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), rubles

As shown in figure 9, the average level of salary within the upper level of the manufacturing technology chain of petrochemical complex (production of rubber and plastic products) in 2019 amounted to only 35.3 thousand rubles, which is 16.7% lower than the average in the regional economy. Strategically, this can lead to lower productivity in the industry, high risks of opportunistic personnel behavior. Accordingly, ensuring the intensive growth of average salary within the companies of this technological shift is a task that is important for increasing the efficiency of the development of the manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan as a whole.

III.VII Structure of production costs

The structure of production costs provides some information on the development of production activities of the manufacturing technology chain levels in petrochemical complex of the Republic of Tatarstan (figures 10-13).

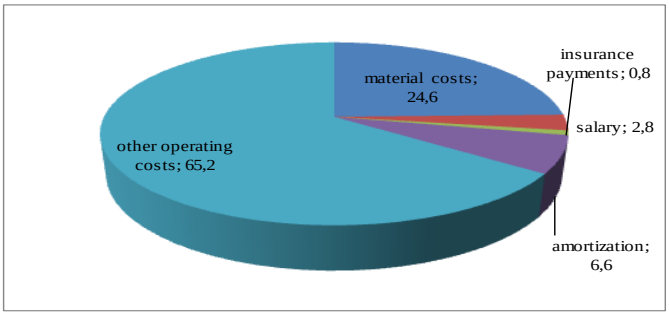

Figure 10. The structure of production costs in the oil

extraction of the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), 2018, %

As shown in Fig. 10, the largest element in the structure of production costs of the oil extraction in the regional economy of the Republic of Tatarstan is other operating costs. Moreover, in 2012-2018 this element of the structure of production costs of the investigated initial level of the manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan increased by 4.1 percentage points. The matter is that the structure of other operating costs, according to the operating methodology of statistical account, pre-production costs which are major ones in the oil-extracting industry [7].

As shown in figure 11, material costs are the main element of the cost structure in the oil refining. Rather high material consumption of the industrial products is, one of the factors for limiting the growth of profitability of the products.

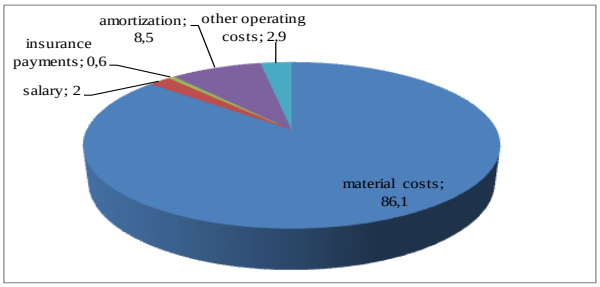

Figure 11. The structure of production costs in oil refining of the Republic of Tatarstan (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), 2018, %

The structure of production costs in the chemical industry of the Republic of Tatarstan (figure 12) is rather balanced, generally congruent, similar to the structure in the chemical production of the Russian Federation as a whole.

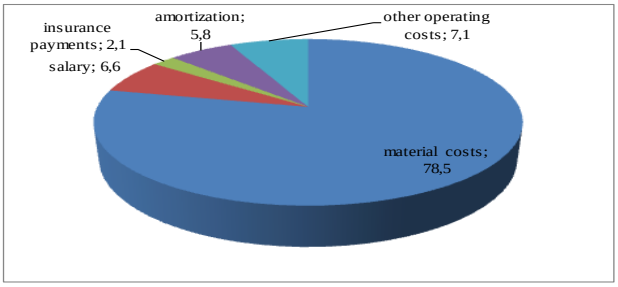

Figure 12. The structure of production costs in chemical production of the Republic of Tatarstan, 2018 (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), %

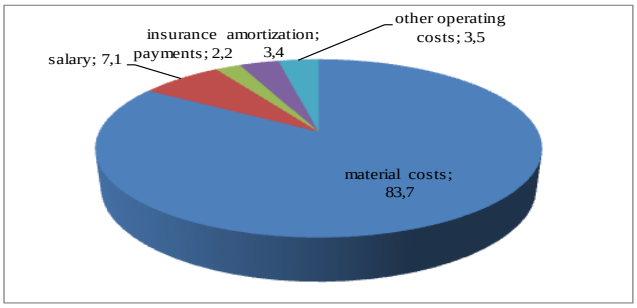

Figure 13. The structure of production costs in rubber and plastic products manufacturing in the Republic of Tatarstan, 2018 (Materials of the Ministry of Industry and Trade of the Republic of Tatarstan), %

As shown in figure 13, the share of material costs makes in cost structure of rubber and plastic products manufacturing of regional economy in the Republic of Tatarstan 83.7% while, for example, in the similar industry of the countries of the EU the similar indicator was only 74.1% in 2018 [3]. Accordingly, the high level of materials is a limitation of the growth of sales volume in the rubber and plastic products manufacturing due to the insufficient level of competitiveness of products, and prevents intensification of the profitability increase, and creates restrictions for the previously identified such pressing industrial problem as the rather low level of average salary.

Thus, according to the sectors of the manufacturing technology chain of the petrochemical complex in the Republic of Tatarstan, the general current directions of rationalization of the cost structure are to ensure reduction of the share of material costs due to intensification of the introduction of resource-intensive, first of all, energy-efficient production MM technologies, as well as to consistently reduce the share of other costs - the least non-transparent element of the structure of production costs.

III.VIII Simple linear regression analysis of manufacturing technology chain development in petrochemical complex of the Republic of Tatarstan

Economic and statistical tools can be used to assess the efficiency of the manufacturing technology chain formation and development in the petrochemical complex of the Republic of Tatarstan. In our point of view, the functioning of the manufacturing chain is the more efficient the more elastic the influence of the lower level of the chain on the development of the corresponding upper level. At the same time, the most preferable version of the function of this kind of influence is given in figure 14.

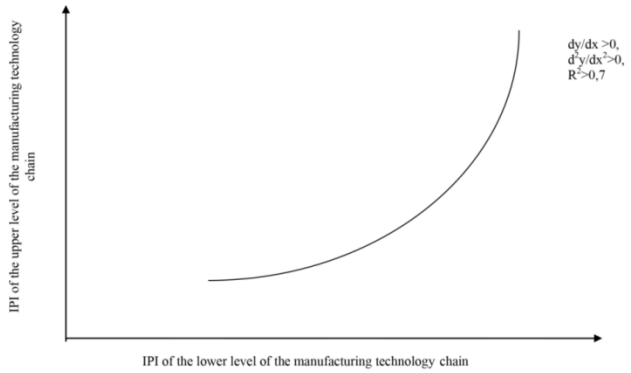

Figure 14. Dependence between the dynamics of IPI at integrated levels of the production and technological chain (based on author's research)

According to this approach we will assess the efficiency of the development in the manufacturing technology chain of the petrochemical complex in the Republic of Tatarstan in 2012-2019.

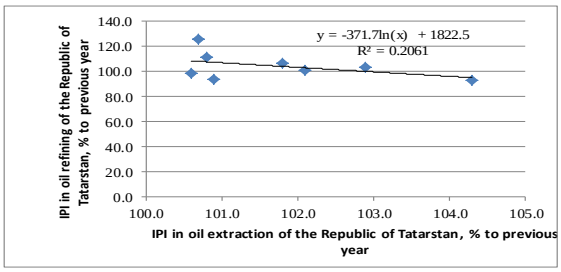

Figure 15. Impact of IPI in oil extraction on IPI in the oil refining of the Republic of Tatarstan, 2012-2019 (source: authors' calculations)

The key direction of integration within the manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan is the interaction of oil extraction and oil refining industries. However, as shown in figure 15, the actual function of the impact of the development rate of regional oil extraction on the dynamics of change of IPI in the oil refining differs significantly from the theoretically optimal one shown in figure 14.

The function is statistically insufficiently stable, as evidenced by the low value of coefficient of partial determination R^2. In addition, this function is anomalous, decreasing, indicating a lack of integration between the levels of the manufacturing chain. In our view, one of the main reasons for this imbalance is the greater dependence of the development rate of the regional oil refining complex on difficult-to-predict fluctuations in the industrial markets than on the quality of formation and implementation of integration mechanisms with the regional sphere of oil extraction. In addition, in the stable situation of domestic and world crude oil prices of PJSC TATNEFT, oil exports are more profitable than its deliveries on the domestic market, including for the purpose of ensuring the production activity of JSC TANECO.

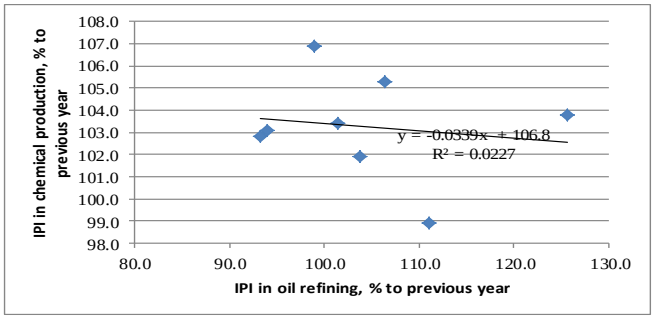

Figure 16. Impact of IPI in oil refining on IPI in chemical production of the Republic of Tatarstan, 2012-2019 (source: authors' calculations)

As shown in figure 16, the efficiency of processes in integration of such levels of the manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan by the congruence of the dynamics of indices in production volume is also insufficient. One of the main reasons for this trend is the imbalance of a portfolio of purchases of a number of the organizations in the regional chemical industry, their orientation not only to regional suppliers of raw materials [8].

The function reflecting the integration processes between the two upper levels of the manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan (chemical production and rubber and plastic products manufacturing) is shown in figure 17.

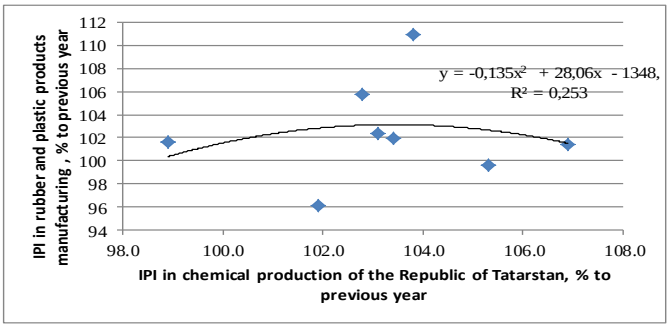

Figure 17. Impact of IPI in chemical production on IPI in rubber and plastic products manufacturing of the Republic of Tatarstan, 2012-2019 (source: authors' calculations)

As shown in figure 17, in 2012-2019 the function of the influence of IPI in the field of chemical production on the dynamics of the index of the physical volume of rubber and plastic products manufacturing in the regional economy of the Republic of Tatarstan is also insufficiently statistically stable, as evidenced by the relatively low value of the mutual determination coefficient (R^2 = 0.253). In fact it shows that the development of rubber and plastic products manufacturing of the regional economy in the Republic of Tatarstan has depended by 25.3% on the pace of development and,

accordingly, on the intensity of integration with enterprises of the chemical industry in the region, and by 74.7%, respectively, on other factors, such as the quality of management, productivity, dynamics of industrial markets, etc.

It should be noted that at least up to 104.0% the cuspidal function is increasing. In this range the positive effect of integration at the considered levels of the manufacturing technology chain in petrochemical complex takes place.

Correlation of labour and capital (the main conditions of ensuring effectiveness of financial and economic activity) can also demonstrate efficiency of development at levels of the manufacturing technology chain in the petrochemical complex. At the same time the following options of impact of fixed assets costs on dynamics of number of industrial personnel at the enterprises of appropriate level of the manufacturing technology chain are possible:

- Inverse dependence indicating a tendency of interchangeability of labour and capital within the appropriate level of the manufacturing technology chain;
- Direct dependence showing intensive development of the chain level in terms of use of labour and capital (process of simultaneous increase of residual value of fixed assets and involvement of additional volumes of labour in production activity);
- Non-monotonic dependence with an extreme point, indicating that there is some optimal relationship between labour and capital within the investigated level of the manufacturing technology chain;
- Lack of a statistically significant relationship, indicating a lack of balanced management of labour and capital within the investigated level of the manufacturing technology chain in the petrochemical complex.

The economic and statistical function of the effect of the residual value of fixed assets on the dynamics of the number of industrial personnel in the oil extraction of the Republic of Tatarstan is shown in figure 18.

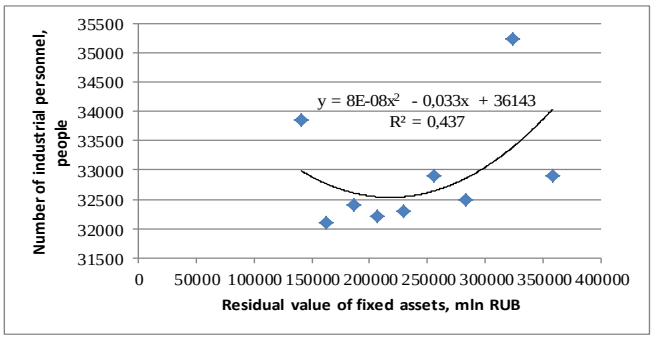

Figure 18. Impact of cost of capital on dynamics of labour resources in oil extraction of the Republic of Tatarstan (2010-2018) (based on authors' research))

As shown in figure 18, for the sphere of oil extraction in the Republic of Tatarstan there is a polynomial dependence of the dynamics of labor resources on the cost of fixed assets, characterized by the average level of statistical stability according to the factor of partial determination. With the value of fixed assets exceeding 250 billion rubles, accordingly, there is an increasing trend in the impact of the cost of capital on the number of industrial personnel. This trend is related to the fact that in 2015-2018 active investment processes in oil extraction were accompanied by processes of optimization of composition and structure of labor resources (some reduction of number of production workers due to intensification of processes of labor automation and parallel certain increase of number of engineers and technicians and certain categories of administrative and management personnel).

The function of the impact of capital cost dynamics on the number of industrial personnel in the oil refining of the regional economy in the Republic of Tatarstan is shown in figure 19.

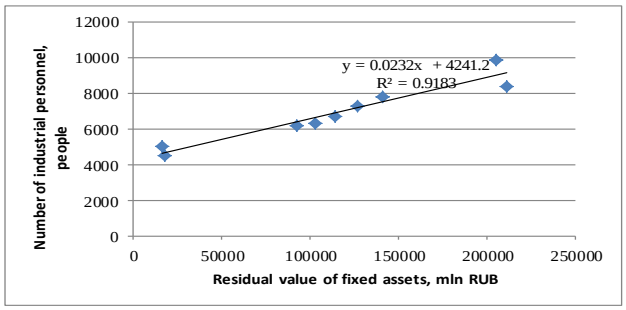

Figure 19. Impact of cost of capital on dynamics of labour resources in oil refining of the Republic of Tatarstan (2010-2018) (based on authors' research)

As shown in figure 19, the oil refining in the regional economy of the Republic of Tatarstan is characterized by a statistically stable increasing function of the impact of the cost of fixed assets on the dynamics of the number of personnel. Such function indicates rather intensive management of production factors within this level of the manufacturing technology chain in petrochemical complex, parallel processes of investment activity and involvement of additional labour resources in production (within the framework of capacity increase of JSC TANECO). At the same time, the obtained function is linear, which indicates that there is insufficient margin effect of mutual factors of labor and capital in oil extraction of the economy in the Republic of Tatarstan.

A similar function in the chemical production of regional petrochemical complex is shown in figure 20.

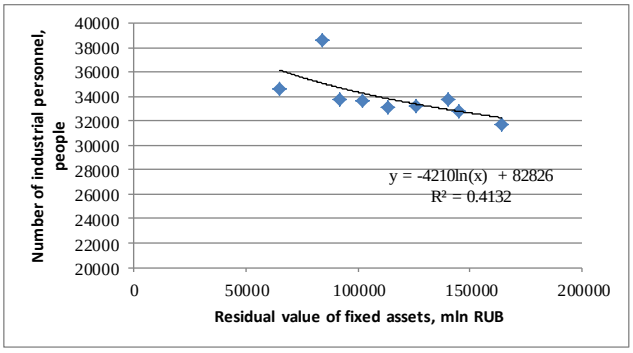

Figure 20. Impact of cost of capital on dynamics of labour resources in the chemical production of the Republic of Tatarstan (2010-2018) (based on authors' research)

As shown in figure 20, the chemical production tends to be interchangeable between labour and capital, approximated by a decreasing logarithmic function. In 2010-2018, the trend of increasing the residual value of fixed assets, due to the intensification of the implementation of investment programs of industrial enterprises, was accompanied by a certain decrease in the number of industrial personnel, connected with the activation of processes in automation of labour activity. At the same time, some employees were transferred to satellite enterprises in the petrochemical cluster of the Republic of Tatarstan - organizations providing transport, logistics, information, consulting and other services for large industrial enterprises of the complex.

Statistical model of the effect of the residual value of fixed assets on the dynamics of the number of industrial personnel in the rubber and plastic products manufacturing of the Republic of Tatarstan is shown in figure 21.

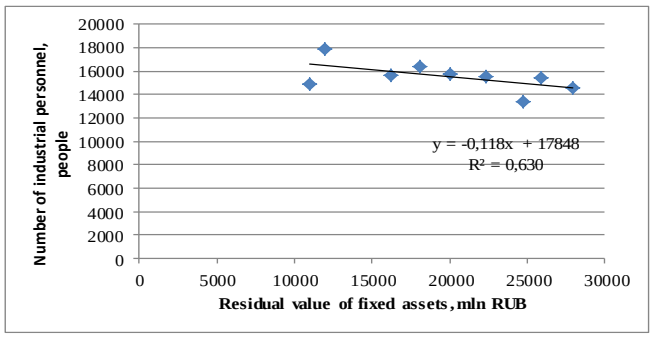

Figure 21. Impact of the cost of capital on the dynamics of labor resources in the rubber and plastic products manufacturing of the economy in the Republic of Tatarstan (2010-2018) (based on authors' research)

However, as shown in figure 21, the trend of interchangeability of labor and capital in the rubber and plastic products manufacturing (the top level of the manufacturing technology chain in the petrochemical complex of the Republic of Tatarstan) is characterized by rather low level of elasticity.

IV. CONCLUSION

In conclusion, our approach makes it possible to study trends of mutual factors of labor and capital at different levels of the manufacturing technology chain of the petrochemical complex of the regional economy in the Republic of Tatarstan. Further intensification of integration processes within this chain, all other things being equal, will improve the level of balance in use of factors of production in the sectors of the petrochemical complex in the regional economy.

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REFERENCES

[1] "Materials of the Federal State Statistics Service of the Republic of Tatarstan."

[2] "Materials of the Ministry of Industry and Trade of the Republic of Tatarstan."

[3] Russia and Countries of the World: statistical yearbook. Rosstat M. 371 p.

[4] Russian Economy: Trends and Outlooks. M.: Gaidar Institute Publishers. 2019:387 p.

[5] Russian statistical yearbook. Rosstat M. 2019:517 p.

[6] Regions of Russia: statistical handbook. Rosstat M. 2020:427 p.

[7] Safina AA. Ocenka vliyaniya proizvodstvenno-tehnologicheskih cepochek na formirovanie novogo tehnologicheskogo uklada.Avtoref. dis. k.e.n., Kazan'. 2013:24 s.

[8] Safiullin MR. Metodologiya upravleniya jekonomicheskoj sistemoj pri pomoshhi investicij i zanyatosti. Avtoref. dis. d.e.n., Kazan. 1996:38 s.

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