Investment-innovation analysis of interactions between technological and economic aspects of industrial development of mineral resources in the Arctic

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Investment-innovation analysis of interactions between technological and economic aspects of industrial development of mineral resources in the Arctic

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Abstract. The methodological foundations of investment-innovation analysis for the objective determination of innovation-active enterprises are considered. The particular importance of managing the implementation of new technologies for industrial enterprises operating in the Arctic is noted. The main factors that influence the change in the manufacturability level coefficient value which reflects the proportional dependence of the material intensity of the product from the capital intensity of production are identified. The characteristic of each factor is presented. It was determined that the main influence on the change in the values of the coefficient is made by the rate of renewal of the fixed assets active part of enterprises - machines, equipment and vehicles. The sequence of investment-innovation analysis implementation by the retrospective data of enterprises is presented. A method for determining the completion period of each of the six stages of the technological development life cycle is shown. It is determined that the decrease of the manufacturability level coefficient value or the instability of the stages of the production process life cycle are associated with the low efficiency of the enterprise management process what makes it possible to carry out an economic assessment of the damage from increase of production cost price and decrease of profit as a result of poor management at any level of hierarchy.

1. Introduction

The economy of the Arctic regions has mainly raw materials direction. The industry is dominated by mining and primary processing of mineral, fuel and energy resources.

For the Russian economy the development of natural resources is of strategic importance [1,2]. Currently a strong industrial layer has already been created in the Arctic regions Oil and gas extraction takes a leading place in the industrial structure of the Arctic. The main share of world diamond production and primary production of apatite, phlogopite antimony, barite, vermiculite, rare metals are concentrated in the Arctic. Nickel-cobalt industry produces the majority of platinoids, nickel, cobalt, and copper. Fish industry produces a third of Russian seafood and more than 20% of canned fish [3,4].

However, when justifying the prospects for increasing the extraction and processing of minerals it must to consider that, firstly, the industry in such regions is more capital intensive since it is necessary to develop new fields located in hard-to-reach areas with complex mining and geological conditions of mining especially as equipment have to work in harsh climatic conditions. Secondly, the growth rates

of labor productivity in such conditions of the industry functioning should be higher than in the country's economy as a whole since living conditions are unattractive for an additional inflow of labor. Thirdly, the natural environment in the Arctic is extremely vulnerable to emissions of pollutants from industrial enterprises. [5,6]. Accordingly, the state in the arctic regions should ensure a focused industrial policy to intensify the development of newest technologies and the use of the new high-performance equipment. [7,8].

It should be noted that the innovative potential of the regions is not fully exploited in the Arctic. [9]. For example, the domestic costs for research and development in total volume of the Russian gross regional product are significantly higher than the same indicator for the Arctic regions. At the same time the task of enhancing innovative activity should be addressed not only at the state level but also at the level of individual industrial enterprises [10, 11]. However, at the same time the management of enterprises should consider the expediency and necessity of introducing technological innovations, that is, their influence on increasing the economic efficiency of production. It should be noted that the existing methodology for assessing the effectiveness of investment projects implementation does not solve this problem due to several reasons. [12,13]. Accordingly, the purpose of the study is to reveal the relationship of technological innovations and profitability of the enterprises by indicators of economic efficiency of production resources use.

2. Materials and methods

In the developed methodology for assessing the impact of technical progress on the effectiveness of production systems it is shown that any industrial enterprise can develop depending on the effectiveness of the resources used in four directions: innovative-efficient when simultaneously decreases the material intensity of products (MI) and increases the level of capital efficiency (EC); innovative-inefficient when simultaneously decreases MI and EC; non-innovative- efficient when simultaneously increases MI and EC; non-innovative-inefficient when increases MI and decreases EC. It was revealed that between the values of MI and capital intensiveness (CI) there is a proportional dependence which is reflected by the manufacturability level coefficient (k). As a result, two directions of enterprise development (innovative-efficient and non-innovative-inefficient) can be implemented in two versions depending on the direction of change in the values of the coefficient, that is, their increase or decrease [14].

Interrelation of development directions of enterprises and their variants are reflected by the life cycle of technological production including six stages. At the same time the growth of the manufacturability level coefficient value of production is ensured only at three interrelated stages but a *simultaneous* increase in the efficiency of all three types of the economic resources is possible only at one stage of them. This stage corresponds to the first variant of the innovation-efficient development direction of the enterprise. In a transition of the enterprise to the second development variant in this direction (the next stage) manufacturability level coefficient value starts to decrease what is a signal for the enterprise to reduce the efficiency of the production technology used [15].

In fact, the activity of each enterprise can correspond to any stage therefore it is necessary to analyze each stage separately as well as to consider the expediency of transition from one stage to another. When performing such an investment-innovation analysis the main importance is the study of factors affecting the change in the manufacturability level coefficient values.

3. Results

A study of the activities of large Arctic industrial enterprises revealed six main factors: inflation, type of activity, fixed assets wear level, structure of fixed assets of an enterprise (ratio of active and passive parts), rates of renewal of fixed assets, level of efficiency of enterprise management.

The following shows the characteristics of possible influence of each factor separately. There is no doubt that inflation has, on the one hand, a significant influence on the change in the value of material resources used in production and ,to a lesser extent, on the change in the value of fixed assets since they have been updated for many years. As a result, due to inflation, the manufacturability level

coefficient value decreases slightly. Accordingly, when carrying out an investment-innovation analysis on an enterprise this should be taken into account at least by bringing the prices of material resources into a comparable form over the entire analysis period if it includes several years. On the other hand, enterprises get real profits not conditionally calculated ones therefore in order to increase profits it is necessary to manage an enterprise in such way as to take into account and overcome the effect of all objective factors reducing this profit.

The type of activity of an enterprise objectively affects the absolute of the manufacturability level coefficient value since enterprises may be more or less capital intensive depending on the specifics of the activity. For example the mining industry is generally more capital intensive than the processing one especially if ore is mined underground. However in carrying out investment-innovation analysis trends in the manufacturability level coefficient values rather than their absolute values are important.

At first glance fixed assets wear level should significantly affect the change in the value of k since it is obvious that with a high degree of wear it is extremely difficult to achieve a reduction in the material intensity of products. Nevertheless a performed analysis of the effect of fixed assets wear on the dynamics of the manufacturability level coefficient values by calculating the capital efficiency through the initial and residual value of fixed assets in two large enterprises located in the Arctic (PJSC Alrosa and JSC Kola MMC) for the period 2011 -2017 showed that the trends of the coefficient values change in both cases are the same (table 1 and 2).

The results of the analysis given in table 1 and 2 show that manufacturability level coefficient values were not affected by the ratio of active and passive parts of fixed assets of the enterprises since they have this ratio different due to the specifics of the activity. However trends in the changes of capital efficiency level calculated over the entire amount of fixed assets and separately by the volume of their active part including equipment and vehicles were the same at both enterprises.

The rate of renewal of fixed assets of enterprises and above all their active part that is machinery, equipment and vehicles has the greatest impact on increase of manufacturability level coefficient values. Thus it can be assumed that the growth dynamics of the value of the coefficient is determined mainly by the rate of implementation of technological innovations on enterprises.

However, since the increase of manufacturability level coefficient values is not always associated with a simultaneous increase in capital efficiency and a decrease in material intensity it is necessary to take into account the annual rate of change in the values of these indicators during the process of investment-innovation analysis. It allows to determine the number of direction and its variant of enterprise development for each year as well as a quarter or a month (if necessary) of the retrospective period. They correspond to certain stages of the technological development cycle of an enterprise and allow considering its economic activity in a more substantively way from the point of view of the efficiency of the resources used.

A detailed investment-innovation analysis for the last reporting year (by quarter) or quarter (by month) should give a representation of sustainability of the developmental stage if it does not change over several quarters or months. Further, if the stage is stable then it is necessary to determine the period of time until its completion. To do this it is necessary to determine the decrease trend of the growth rates of the base values for each stage of the indicator - either material efficiency (ME) or capital efficiency.

In cases where in the last reporting period (year or quarter) the development stage of an enterprise is unstable, that is, there is a change of stages that are not interrelated this may indicate inefficient production management at lower levels of the management hierarchy — in workshops, sites and brigades. It results in a reduction in the demands of management towards subordinates, a violation of labor and production discipline and accordingly an increase in manufacturing defects, an excess of material resources consumption norms, an increase in equipment downtime, etc. In such cases, investment-innovation analysis should be carried out at these levels of management.

Table 1. Main economic indicators of technological development of PJSC Alrosa for 2011-2017.

Indicators	Unit	2011	2012	2013	2014	2015	2016	2017
Material intensity	Rub/ rub	0,250	0,273	0,272	0,244	0,185	0,143	0,170
Capital efficiency of fixed assets at original cost (at the end of the year)	Rub/ rub	0,603	0,598	0,616	0,657	0,525	0,686	0,537
Manufacturability level coefficient	Rub/ rub	6,64	6,19	6,00	6,33	8,64	10,19	10,96
Development direction number	№	1-2	4-1	1-2	1-1	2	1-1	4-2
Capital efficiency of fixed assets at residual cost (at the end of the year)	Rub/ rub	0,880	0,886	0,945	1,022	0,880	1,144	0,914
Manufacturability level coefficient	Rub/ rub	4,55	4,18	3,89	4,01	5,14	6,11	6,44
Development direction number	№	1-2	3	1-2	1-1	2	1-1	4-2
Capital efficiency of active part of fixed assets at original cost (at the end of the year)	Rub/ rub	1,992	1,776	1,934	2,033	1,845	2,427	1,936
Manufacturability level coefficient	Rub/ rub	2,01	2,09	1,91	2,05	2.46	2,88	3,04
Development direction number	№	1-2	4-1	1-2	1-1	2	1-1	4-2
Capital intensiveness of active part of fixed assets at residual cost (at the end of the year)	Rub/ rub	5,181	3,937	4,762	4,950	5,208	6,410	5,225
Manufacturability level coefficient	Rub/ rub	0,77	0,93	0,77	0,83	0,87	1,09	1,13
Development direction number	№	1-2	4-1	1-2	1-1	1-1	1-1	4-2
Capital equipment of labor at original cost of fixed assets (at the end of the year)	Th. rub/ person	6450	6939	7405	8134	11966	13199	14042
Labor productivity	Th. rub/ person	3888	4152	4564	5310	6280	9057	7536

Table 2. Main economic indicators of technological development of JSC Kola MMC for 2011-2017.

Indicators	Unit	2011	2012	2013	2014	2015	2016	2017
Material intensity	Rub/ rub	0,341	0,360	0,376	0,299	0,307	0,385	0,395
Capital efficiency of fixed assets at original cost (at the end of the year)	Rub/ rub	1,363	1,188	0,949	1,141	1,167	0,953	0,957
Manufacturability level coefficient	Rub/ rub	2,15	2,34	2,80	2,93	2,79	2,73	2,64
Development direction number	№	4-1	4-2	4-2	1-1	3	4-1	3
Capital efficiency of fixed assets at residual cost (at the end of the year)	Rub/ rub	2,272	2,095	1,761	2,181	2,291	1,954	1,869
Manufacturability level coefficient	Rub/ rub	1,29	1,33	1,51	1,53	1,42	1,33	1,35
Development direction number	№	4-1	4-2	4-2	1-1	3	4-1	4-2
Capital efficiency of active part of fixed assets at original cost (at the end of the year)	Rub/ rub	2,369	1,973	1,555	1,847	1,835	1,481	1,436
Manufacturability level coefficient	Rub/ rub	1,24	1,41	1,71	1,81	1,77	1,75	1,76
Development direction number	№	4-1	4-2	4-2	1-1	4-1	4-1	4-2
Capital efficiency of active part of fixed assets at residual cost (at the end of the year)	Rub/ rub	4,831	4,170	3,488	4,207	4,169	3,356	3,123
Manufacturability level coefficient	Rub/ rub	0,61	0,67	0,76	0,79	0,78	0,77	0,81
Development direction number	№	4-1	4-2	4-2	1-1	4-1	4-1	4-2
Capital equipment of active part of fixed assets at original cost (at the end of the year)	Th. rub/ person	1971	2149	2299	2417	2612	2835	3994
Labor productivity by sales revenue	Th. rub/ person	4670	4241	3575	4463	4792	4287	3822

In general this is the impact on the efficiency of economic resources use of the subjective factor at the lower levels of management. At the upper levels (top management) this factor is especially

significant and shows that the company's management does not evaluate or cannot objectively assess the need for timely technological renewal of production. These considerations make it possible to carry out an economic assessment of damage from an increase of the production cost price and a decrease of profit resulting from poor management at any level what greatly increases the importance and necessity of the new economic analysis under consideration.

4. Conclusions

1. The importance of using a new direction of economic analysis of enterprises (investment-innovation) to substantiate the prospects for the development of industrial enterprises operating in the Arctic was determined.

2. Characteristic of the main factors influencing the change of the manufacturability level coefficient value which is the basis for the implementation of investment-innovation analysis is presented. It is shown that the main objective factor is the renewal rate of the fixed production assets active part of enterprises. The procedure for a retrospective investment-innovation analysis is considered.

3. It is determined that decrease of the manufacturability level coefficient value or instability of the stages of the life cycle of manufacturability are connected with the low efficiency of the enterprises activities management. It allows to perform an economic assessment of damage from increase of production cost price and decrease of profit resulting from poor management at any level of the management hierarchy.

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