Modeling of added value of high-tech industries based on aluminium

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Abstract. The article proposes a model for assessing the efficiency of the cluster to predict the potential value and structure of value added for promising products and technological chains of their production. The ratio of added value as a result of the cluster operation to the volume of revenue from sales was chosen as the resulting indicator. The choice is due to the possibility of using this ratio as a multiplier of value added. Independent groups of factors - internal (depreciation; payroll; profit) and external market factors determining the upper limit of value added formation (the scale of the national market and the market share controlled by the cluster). Presents major phases in the simulation: predict the relative resultant figure to 2020 based on extrapolating actual values for 2010-2016 for the structure of value added elements (amortization, payroll; profit) and stages of the technological chain of the cluster – production of alumina, production of aluminum and alloys, production of intermediate products, production of final products; assessment of the potential value and structure of value added from the production of promising products in 2020 A mechanism for assessing changes in the value added as a result of management of the value of internal factors at each stage of the technological chain is developed, which allows to optimize management decisions and create alternative scenarios for increasing the added value in the technological chain of the cluster. Testing of the proposed model to estimate the value and structure of value added by types of promising products in the elements of the cluster "Technological valley" in accordance with production scenarios is presented.

1. Introduction

Value chains, being an effective management tool that allows to clearly identify the strategic priorities of the development of companies, in the conditions of instability of the external environment allow to concentrate production, cash and commodity capital, to increase the speed of its reproduction, to introduce innovations, to produce products with high added value, to enter the world markets. As the modern economy goes on the way of complication of forms of the organization of business and ways of coordination of activity of economic entities new modern analytical tools of decision-making are necessary.

Generalization of the research results in this direction does not allow today to approach the problem of determining value chains in the framework of international cooperation, taking into account the...
industry characteristics of industrial markets, forms of business organization, the criteria for the formation of relationships and their results. This determines the relevance of the study for the emerging regional industrial cluster «Technological valley» [2].

The purpose of the article is to develop a model for assessing the efficiency of the cluster based on the prediction of the value added value and structure for promising products and technological chains of their production. The difference of this approach is taking into account in the size and structure of the added value of both already manufactured products and planned for production by optimizing the choice of options for the production of new high-tech products from the perspective of expanding the range of the cluster and strengthening the market power of manufacturers. The study is based on theoretical generalizations made both on the basis of the works of classics and scientists in the field of institutional theory, economic sociology and firm theory, and on examples from the practice of business in various sectors of the economy [1; 2, 3, 5, 6, 7, 8].

2. Methodology
The cluster efficiency model can be presented in the following form. As a result, it is advisable to consider the ratio of value added (added value, \( AV \)) obtained as a result of the operation of the cluster, to the volume of output represented in the model of sales revenue (revenue from sales, \( RS \)). The choice of the \( AV/RS \) indicator is due to its economic essence and the possibility of using it as an indicator (multiplier) of added value: the higher value of this indicator goes to the greater difference between the value of the goods produced and the value of primary raw materials involved in economic turnover, the greater the number of stages of the technological chain and processing passes the product until its transformation into a final product [3].

The possibility of forming the added value of the cluster is determined by two groups of factors:
- **internal managed factors**: depreciation (deprecation, \( D \)); wage fund (wage fund, \( WF \)); profit (profit, \( P \));
- **external market factors determining the upper limit (border) of value added formation.** These factors are: the scale of the market and the market share controlled by the cluster in a particular commodity market.

For companies-participants of the cluster it is important to evaluate the size of the indicator \( AV/RS \) and to determine the effectiveness of the control value at each stage of the technological chain: production of alumina, production of aluminium and alloys manufacture of intermediate products manufacture of final products. For this purpose, we will use sensitivity analysis. In a broad sense, sensitivity analysis evaluates the degree of variability of the output parameter to a change in one of the input parameters, provided that the other input parameters remain unchanged [22]. This type of analysis allows to assess the stability of the resulting indicator to changing factors (input parameters). The information base for the sensitivity analysis is the data on the production and commercial activities of companies-potential participants of the cluster. Source of information – Databases of IA SPARK for 2010-2016 [17].

The sensitivity analysis should follow the following algorithm.
1) the values of the output parameter (the ratio of value added to the sales volume of the cluster in value terms) are calculated in the basic scenario for the period of analysis 2010-2016.
2) the values of the input parameters are calculated: managed factors – the ratio of depreciation to revenue, \( D/RS \); the ratio of the payroll to revenue, \( WF/RS \); the ratio of profit to revenue, \( P/RS \) in each element of the cluster (stage of the process chain) for one period of analysis.
3) percent change of input and output parameters relative to the base scenario is calculated.
4) the degree of sensitivity of the output parameter to the change in the input parameters is calculated by dividing the percentage change in \( AV/RS \) by the percentage change in each factor (\( D/RS; WF/RS; P/RS \)).

It should be noted that changes in individual factors affect the ratio of value added (\( AV \)) to revenue (\( RS \)) in each element of the cluster (process chain) in different ways. The sensitivity of the \( AV/RS \) index to changes in the factors affecting its value in each element of the cluster is measured using the elasticity
coefficient at the 4th stage of the algorithm described above. The coefficients of elasticity of the AV/RS index to the change of each internal factor are calculated according to the formula [18]:

\[ e_{F_i}^{AV/RS} = \frac{(F_i^{t1} - F_i^{t0}) / F_i^{t0}}{(AV/RS^{t1} - AV/RS^{t0}) / AV/RS^{t0}} \] (1)

where \( F_i \) – one of the three managed factors (depreciation; wage fund; profit), the percentage of change of which is estimated for the period of analysis 2010-2016; \([t_0; t_1]\) is the analyzed period.

3. Outcomes
The initial data for the sensitivity analysis are formed on the basis of statistics of production of aluminum products for the cluster elements for 2010-2016. The results of calculations of the elasticity coefficients of the AV/RS index for the cluster elements are presented in table 1. The obtained results allow us to identify the optimal management decisions regarding the formation of scenarios for increasing the added value in the technological chain of the cluster.

1. The change in the cluster output structure due to the increase in the specific shares of "alumina" and "intermediate production" by 10 % will increase the AV/RS indicator by almost 20 %: 10% * 0.857 + 10% * 1.119 = 19.76 %.

It can be highlighted the following scenarios of changes in the production structure of the cluster (figure 1):
- increase the base item of the production of intermediate goods;
- expansion of the range of output due to import substitution;
- increase production of alumina by introducing the technology of manufacturing of metallurgical alumina from non-traditional aluminum ore (aluminum oxide).

2. The increase in the share of depreciation in output as a factor characterizes the investment, innovation and technological components of the production process [19]. However, the influence of this factor is not as significant as the factors of output structure. For example, an increase in investment in "alumina production" by 10% will lead to a reduction in the efficiency of the cluster by 0.94%. The same level of dependence is observed in the element "production of intermediate products". The positive impact of the growth of the ratio of depreciation and the release of characteristic elements of the "manufacture of aluminium and alloys" (the 0.383) and "manufacture final product" (0.10). The increase of investments by 10% in "production of aluminum and alloys" and "production of final products" will increase the efficiency of the cluster (indicator AV/RS) 4.83%: 10% * 0.383 + 10% * 0.10 = 4.83 %.

Table 1. The result of the calculation of elasticity values of AV/RS to changes in managed factors (RS/RS, D/RS, WF/RS, P/RS)

| Factors | Relative change over the period 2010-2016 | The elasticity AV/RS to change factor 1% |
|---------|------------------------------------------|----------------------------------------|
| Te value added to revenue from sales (AV/RS) | -0.088391 | |
| Share of production in total revenue from sales (RS/RS) | |
| alumina production | -0.103116 | 0.857 |
| production of aluminium and alloys | 0.009145 | -9.666 |
| production of intermediate products | -0.079023 | 1.119 |
production of final products  
Depreciation to revenue (D/RS)  
alumina production  
production of aluminium and alloys  
production of intermediate products  
production of final products  
Wage fund to revenue (WF/RS)  
alumina production  
production of aluminium and alloys  
production of intermediate products  
production of final products  
Profit to revenue (WF/RS)  
alumina production  
production of aluminium and alloys  
production of intermediate products  
production of final products  

The main scenarios of changes in the production structure of the cluster, which can increase the share of depreciation in output (figure 1):
- expansion of the basic nomenclature of final products;
- increasing the range of production of production of aluminium and alloys in the group "aluminium hydroxide catalysts for petroleum refining", "aluminum alloy, aluminum-scandivia alloys", "high strength cast alloys for use in mechanical engineering on the basis of aluminium".

3. The increase in the share of the wage fund in the output of the cluster will not cause a positive effect (growth of AV/RS) at such stages of the technological chain as: production of alumina, production of aluminum and alloys, production of intermediate products. However, at the stage of production of final products, an increase in the WF/RS index can cause an increase in the efficiency of the cluster, an increase in WF/RS by 10% will provide an increase in the AV/RS index by 14.98%: 10%*1.498 = 14.98%.

Thus, increasing the efficiency of the cluster by increasing the share of the wage fund in total revenue is appropriate only for the element "Production of final products" (figure 1). Among the scenarios of changes in the structure of production are considered:
- increase in the output of the basic nomenclature of the final product;
- expansion of the basic nomenclature of output of final products through import substitution.

4. The influence of the P/RS factor (return on sales) is more noticeable. Thus, the growth of profitability of sales for the elements of the production chain "production of aluminum and alloys", "production of final products" and "production of net products" by 10% will lead to an increase in the efficiency of the cluster by 2.39%, 2.71% and 1.19%, respectively.
- the amount of effective market demand, limiting the size of the potential revenue of the cluster;
- assessment of the most likely market share growth limiting the size of the cluster's real revenue;
- optimal AV/RS ratio for this industry sector.

Evaluation of the potential value and structure of value added by types of promising products in the cluster elements by 2020 involves the following steps:
1. Forecast the relative index of the AV/RS until 2020 based on extrapolating actual values for 2010-2016 On the basis of the obtained values of the relative index of the AV/RS until 2020 is built inertial scenario of the forecast of value added in the corresponding element of the cluster.
2. Forecast of the value added structure by elements (depreciation; payroll; profit) and stages of the technological chain of the cluster - production of alumina, production of aluminum and alloys, production of intermediate products, production of final products.

3. The estimation of the potential value and structure of value added (AV) from the production of perspective products (Prd) in 2020 is based on the following provisions:

- the potential amount of revenue in 2020 is determined by the solvent market demand for each product (Prd) in accordance with the import substitution program of the Russian Federation;
- the real revenue of the cluster on products (Prd) in 2020 is determined by the share of the Krasnoyarsk territory in the potential revenue of the national market.

The input parameters:
- effective market demand for each product (Prd) controlled by national producers in 2020 (RS20(Prd)RF);
- effective market demand for each type of product (Prd), controlled by producers of the Krasnoyarsk territory in 2020 (RS20(Prd)KK);
- a relative measure of the AV/RS in 2020 (AV/RS20 is the result of phase 1);

structure of value added elements (depreciation; payroll; profit) and the stages of the technological chain of the cluster in 2020 (the result of step 2)
Figure 1. The distribution of promising products of the cluster at the scale of the market and stages of the technological chain
Formulas for calculation:

- value added in 2020 on the national market:
  \[ AV_{20} = RS_{20} \times \frac{AV}{RS_{20}}; \]

- value added in 2020 in the cluster:
  \[ AV_{20} = RS_{20} \times \frac{AV}{RS_{20}}; \]

- the value added elements in the cluster are determined based on the size of the AV20 and its structure as predicted in step 2 of this methodology.

It should be noted that due to the lack of information certainty, it is advisable to assess the potential value and structure of value added by types of cluster products for several scenarios:

- **an inertial scenario** does not imply significant changes in the technologies and types of products used, and therefore the relative \( AV/RS_{20} \) is determined on the basis of extrapolation of retrospective values (the result of stage 1);

- **an optimistic scenario** involves the introduction of modern equipment for the production of high-tech products of the cluster. In this case, the relative indicator \( AV/RS_{20} \) is considered as the optimal ratio of value added to sales revenue, established on the basis of expert assessments or experience of achieving a similar indicator in the leading enterprises for this industry sector. In this study, the optimistic scenario is calculated on the basis of the multiplier value (1.7) typical for KAMAZ Automaker in 2016, with \( AV/RS = 0.412 \) [17];

- **a realistic scenario** is seen as the most likely production option in the cluster.

- The results of calculations of the value and structure of value added by types of promising products by 2020 for cluster elements and production scenarios are presented in table 2.

4. **Conclusions**

The modeling of the added value of the cluster on the basis of scenario development options allowed to predict the structure of the added value of the elements (depreciation, payroll, profit) and the stages of the technological chain of the cluster – the production of alumina, production of aluminum and alloys, production of intermediate products, production of final products. The basic assumptions of the simulation were that the potential value of revenue in 2020 could be expected. It is determined by the effective market demand for each type of product in accordance with the import substitution program of the Russian Federation. The real revenue of the cluster for a particular product in 2020 is determined by the share of the Krasnoyarsk territory in the potential revenue of the national market. The introduction of restrictions in the model makes it possible to predict the most likely growth of the market share limiting the size of the real revenue of the cluster and to establish the optimal ratio of value added to sales revenue for a particular sector of industry.

5. **References**

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