Aims & Scope (Economics)

Article

IMPROVEMENT OF COMPLEX INVESTMENT PROCESS MANAGEMENT IN INDUSTRIAL CLUSTER

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Abstract. The article demonstrates features of managing investment activities and projects at the level of an industrial cluster. The necessity to take into account the investment climate and peculiarities of the cluster's investment strategy has been proved in order to identify the sources of investment resources and mechanisms for their involvement in implementation of the selected directions. The economic and mathematical model of investment support of an industrial cluster which is based on a comparative approach to the selection of optimal investment projects from a number of similar starting conditions was built and tested.

Keywords: industrial cluster, investment process, investment project, model of investment support, internal funds, cluster participants.

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Introduction

The effective reform of the national economy of a country is impossible without large-scale investments, which is the most important factor of economic growth and renewal, which provides an opportunity for modernization of existing production facilities, creation and introduction of the latest equipment and technologies, modern systems of organization and management of economic processes, qualitative upgrading of production, transport and market infrastructure. National and local industrial investment processes are characterized by a significant difference between investment inputs and investment needs, reduced volume of investments, deterioration of their technological and regeneration structure, limited capabilities to finance investments from different sources, which, as a whole, have a negative impact on renewal processes in the country and leads to increased levels of risk and create unfavorable conditions for real investment.

Scientific works (Arnold, 2010; Huggins and Hiro 2011; Porter, 2008) reveal a professional opinion that in unstable economic conditions, it seems irrational to rely solely on a market-based mechanism for managing investment activity, which, being essentially a self-regulating and self-adjusting system, in a crisis situation is not able to automatically ensure the efficiency of investment processes. At the same time, a number of researchers (Azman-Saini et al. 2010; de Mel et al. 2008; Masron & Hassan 2016; Storper, 2013) indicate that corporate regulation of investment activity should be a key stimulating factor, support of investments and entrepreneurship for development and efficient functioning of the industrial sectoral and cluster investment sphere.

Scholars such as (Ackert, Deaves, 2010; Aghion et al. 2005; Barca, Fabrizio et al. 2012; Francis, Ibbotson, 2002) indicate that investment management is a system of principles and methods for development and implementation of management decisions, related to implementation of various aspects of industrial investment activity. Such management is an organic part of the overall financial management system, being one of its main functional subsystems, which enables implementation of predominantly strategic decisions within industrial clusters. This list of arguments points to the importance and value of such research and shapes the field for further scientific work in the sphere of industrial investment management.

Methods

As a methodological basis, we have chosen the formats of the country's investment climate, which defines investment activity at the micro level and a risk management model that determines feasibility and security of our own investment. When using the risk approach as a component of the investment climate, we identify three main options for methodological justification: 1) investment potential; 2) investment risks; 3) extended (factor) approach.

1. Cluster investment potential is estimated on the basis of microeconomic characteristics, including: availability of production factors, including human resources; consumer demand; the level of science development and its achievements; development of leading market economy institutions; availability of comprehensive infrastructure (Caniëls & Romijn, 2005).

2. Investment risks are estimated by probability of loss of investment and income. These risks include: economic, financial, political, social, environmental, criminal and legislative. The second variant of the risk approach is based on assessment of investment climate from the point of view of development of the public system of the state as a whole. Among other indicators, human potential, material resources of development, socio-political environment and political risk factors, the state of the economy and the level of its management are taken into account (Lin and Monga, 2011).

3. The extended (factor) approach is based on assessment of a number of factors affecting the investment climate from the perspective of an industrial cluster. Distinctive features of the multifactorial approach to investment climate assessment are: contrariety of categories of the investment climate and the investment risk; relationship between the investment climate and investment in the real economy sector; the objective nature of the assessment of investment climate of the territory, its independence from the behavior of individual investors; the relationship between the investment climate and the fixed capital investment; the multilevel nature of this approach; the relationship between investment climate, investment potential and conditions of investor activity.

Results

3.1. Investment activity at the industrial cluster level

The main goal of managing investment activity at the industrial cluster level is to step up investment activity and create a favorable investment climate within the cluster. To achieve this goal, a number of strategic and tactical tasks should be resolved. Strategic objectives of investment management are tasks aimed at stabilizing and progressively developing the cluster economy; restructuring of the cluster economic complex; creating attractive investment conditions. Tactical tasks of cluster investment management include development of functions and organizational structure of investment activity management at the industrial cluster level; facilitating implementation of investment policy at the level of an industrial cluster; development on its basis and implementation of local investment policy; selection and justification of priority industrial investment objects; improvement of efficiency of investment processes; reduction of the investment risk of cluster companies (Delgado et al. 2016).

The objects of investment activity management at the industrial cluster level are conditions of formation and use of investment resources of different sources of financing, investment complex of the cluster, which include investors, design firms and architecture, infrastructure of the cluster investment market. Directions of cluster investment management are presented in the figure 1.

Cluster investment strategy is a search and selection of market opportunities, as well as a search for investment resources and mechanisms for attracting them to implement the selected

directions. The cluster investment strategy is subordinate to the national overall economic development strategy. On the other hand, an investment strategy, developed in the process of analyzing existing and potential sources and mechanisms of investment financing, has an impact on the overall economic strategy and in some cases leads to its adjustment. Based on the investment strategy at the industrial cluster level, a local investment policy is developed, aimed at creating a favorable investment climate, attracting domestic and foreign investors to the country and the cluster itself.

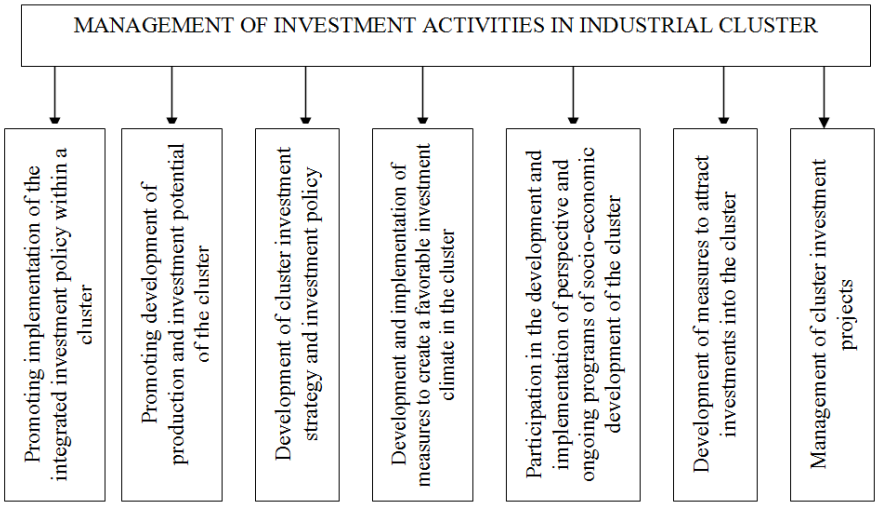

Figure 1. Key directions for managing investment activity at the industrial cluster level
Source: compiled by the authors

Formation of investment policy will require consideration of the following factors of development (Armstrong and Taylor, 2000; Roberts and Enright, 2002):

– strategic socio-economic orientation of the cluster;

– availability of unbiased information for direct formation of investment policy and conducting investment research at the cluster level;

– availability of a professional team capable of developing the cluster investment policy and its further implementation;

– availability of natural, demographic, production, financial resources necessary for practical implementation of cluster investment policy;

– aspects of the cluster investment climate, cluster industrial policy, living standards of the cluster population;

– quantitative and cost parameters of industrial, social and economic factors of cluster investment policy.

3.2. Economic and mathematical substantiation of industrial cluster investment support

Improving the efficiency of managing cluster investment requires development of an appropriate economic and mathematical justification for making decisions on the use of scarce investment resources. A rational combination of investment resources constrained by the cluster's investment capabilities, on the one hand, and diverse investment projects, which is an investment demand within the cluster, requires a mathematical justification for making decisions on financing a local project, allowing the use of scarce resources more effectively (Nicolini, 2001).

It should be noted that there are a number of reasons that complicate creation and use of economic and mathematical models of management processes at the industrial cluster level, which stem from the features of the processes of managing the cluster itself as a system. First, it is the need to accurately formulate a managerial decision to regulate economic processes in uncertainty, secondly, the dynamic environment, which limits the possibility of building an object model, and third, violation of the dynamic equilibrium of the system and environment due to existing disparities in development socio-economic systems. This should be taken into account when making management decisions using mathematical methods. The algorithm for deciding on financing of investment projects from one source or another is presented in Figure 2.

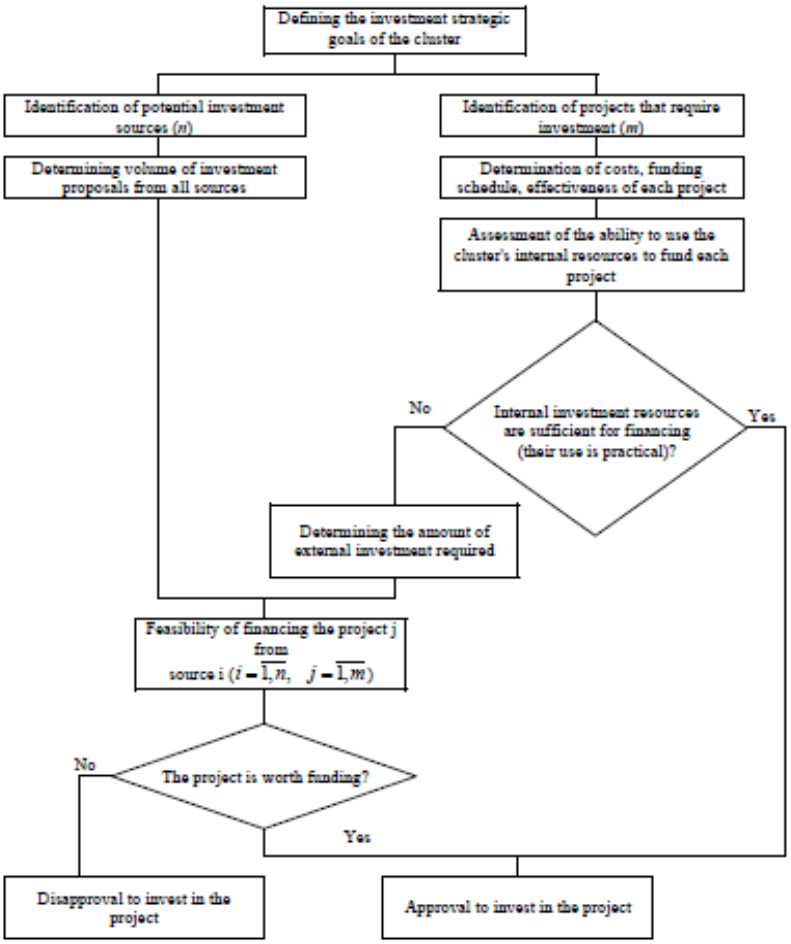

Figure 2. Decision-making algorithm for financing investment projects from industrial cluster internal sources

Source: compiled by the authors

It is proposed to optimize the process of financing investments from different sources in stages, including the following steps:

– identification of potential sources of investment financing and volume of the investment proposal;

– identification of the amount of investment required for the economy, i.e. figuring out investment demand at the industrial cluster level;

– identification of criterion of practicality of financing investment projects within the cluster;

– combination of investment resources with investment projects, i.e. investment supply with investment demand, according to the accepted criterion;

– determination of the optimal structure for allocation of investments from different sources of funding within the cluster (Ketels, Protsiv; 2016).

To solve this task, it is necessary:

– to create an economic and mathematical model for optimizing the use of industrial cluster investment resources;

– to create software and data support of the economic and mathematical model.

The investment demand of an industrial cluster is the total amount of investment required in the manufacturing sector. It consists of many investment projects, each of which corresponds to a certain amount of necessary investments:

$$E = \sum_{j=1}^{m} E_j, \quad (1)$$

where *Ej* - the amount of investment required for the j[th] investment project ($j = 1,\ldots, m$),

m – the number of investment projects.

The investment needed to finance the j[th] project amounts to:

$$E_j = C_j + \sum_{i=1}^{n} K_{ij}, \qquad j = 1,..., m, \tag{2}$$

where *Cj* - own funds of the participating company,
Kij - external investment from the i[th] source into the j[th] project.

The goal is to find the best solution for lodging cluster investment resources. In this connection, first of all, it is necessary to find out whether the companies belonging to the cluster own sufficient funds for implementation of the project. In case of sufficiency (when $E_j \leq C_j$), the company itself finances the project. In case of insufficiency of internal funds or financing from own sources is not planned due to impracticality (when $E_j > C_j$), such project should be considered as potential for external investment.

The amount of investment resources within a cluster is always limited. In this regard, the main stage of finding a solution is to determine the criterion and calculation, according to the accepted criterion, the feasibility of financing a project from external sources. The task is to invest *R* investment resources in *m* investment projects in order to maximize profits (Wilmott, 2009). The most appropriate modeling tool for this process is application of dynamic programming methods based on the Bellman optimality principle.

Let us consider solution of the problem of allocation of S ($S \leq R,\ S \rangle 0$) investment resources between m projects $P_1, P_{2,..}P_m$, which are allocated for one period.

Based on the principle of optimality, the task can be considered as a step-by-step process of managing a system, with the number of steps being equal to the number of investment projects (k = 1, m). And, whatever the state of the S system as a result of any number of steps, the next step is to choose control so that in conjunction with optimal control in all the previous steps it should lead to optimal result in all remaining steps, including this one.

If *xk* is the number of units of the investment resource allocated at the k[th] step, then the probable distribution of investments can be represented as a vector X($x_1, x_2, \ldots x_m$). Let us denote remainder of the investment resource after the k[th] step as *sk*, which depends only on the previous state of *sk - 1* and the control at the k^{th} step as *xk*. The amount of return on investment in a k[th] company can be mathematically expressed as a function of *fk(sk-1, xk)*. The target function is the index of effectiveness of this controlled operation (in this case, total profit) depends on the initial state (of investment resources) and management in the cluster.

$$Z=F(S, X). \tag{3}$$

The target function (3) becomes additive from the index of effectiveness of each step. We denote the index of the effectiveness of the k[th] step as:

$$Zk(sk) = fk(sk - 1, xk), \quad k=1,2,.,m \tag{4}$$

then:

$$Z = \sum_{k=1}^{m} f_k(s_{k-1}, x_k). \tag{5}$$

Thus, mathematically, such problem is formulated as follows: it is necessary to determine such admissible control X, in which the target function (5) acquires the greatest value. The solution to the problem begins with the m^{th} step. Let us denote by $Z_m^*(s_{m-1})$ maximum of the target function - the index of effectiveness of this step, provided that before beginning of the last step the system S was in an undefined state *sk .1*, and at the last step control was optimal. Obviously, the conditional maximum of the target function in the m^{th} step should be equal to:

$$Z_m^*(s_{m-1}) = \max_{\{x_m\}} f_m(s_{m-1}, x_m), \tag{6}$$

*xm=x*m(sm - 1)* - conditional optimal solution at the m^{th} step.

Conducting inductive reasoning and using the reverse move, for the k[th] step we hold the following considerations. We denote by $Z_k^*(s_{k-1})$ a conditional maximum of the target function obtained at optimal control on *n*, - *k* + *1* steps, starting from k to the end, provided that by the beginning of the *k*[th] step the system was in the state *sk- 1*. In fact, this function should be equal to:

$$Z_k^*(s_{k-1}) = \max_{\{(x_k,\ldots,x_m)\}} \sum_{i=k}^{m} f_i(s_{i-1}, x_i). \quad (7)$$

then:

$$Z_{k+1}^*(s_k) = \max_{\{(x_{k+1},\ldots,x_m)\}} \sum_{i=k+1}^{m} f_i(s_{i-1}, x_i). \quad (8)$$

The target function at the *m - k* last steps (Figure 3) at an undefined control *xk* at *k*[th] step and optimal solution at further *m - k* steps should be equal to:

$$fk(sk - 1, xk)+Z^*k+1(sk) \quad (9)$$

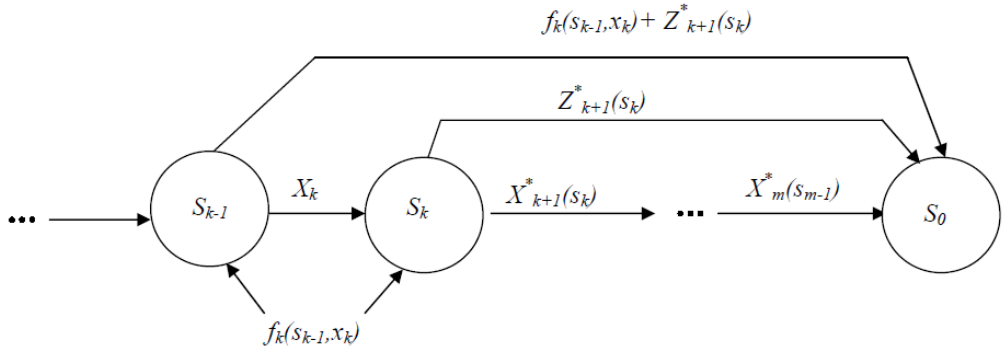

Figure 3. Diagram for optimizing the use of investment resources with the Bellman equation

According to the principle of optimality, *xk* is chosen from the maximum of this sum, i.e.:

$$Z_k^*(s_{k-1}) = \max_{\{x_k\}}\{f_k(s_{k-1}, x_k) + Z_{k+1}^*(s_k)\}, \quad k=m - 1,\ m - 2,.,2,1. \quad (10)$$

Solving the Bellman equation (10), we get a conditional optimal solution at the *k*[th] step - *xk=x*k(sk - 1)*.

As a result of conditional optimization, two sequences are obtained using the recurrence relations (6), (10):

$Z_m^*(s_{m-1}), Z_{m-1}^*(s_{m-2}),\ldots, Z_2^*(s_1), Z_1^*(s_0)$ - optimal volumes of investment in the *j*[th] project *(j=k, j=1,.,m)*;

$X_m^*(s_{m-1}), X_{m-1}^*(s_{m-2}),\ldots, X_2^*(s_1), X_1^*(s_0)$ - balance of the investment fund after each step.

In this case, the maximum profit should be equal to $Z_{\max} = Z_1^*(s_0)$.

Using sequences, conditional optimal solutions and equations of states, we can find solutions to the problem with the *m* and *S*.

The following aspects should be considered when solving the problem (Nofsinger, 2008):

– investments are financed from various sources, the volumes of which are always limited by objective capabilities;

– cluster investment resources should be used to the full, i.e. investment demand and investment supply should be optimally combined;

– the recipient company that needs a certain amount of investment may disagree with the lesser amount proposed for financing;

– first of all, it is necessary to finance projects that give maximum effect to the cluster.

Since optimization of investment resources is considered, first of all, from the point of view of the investor who decides on the financing of the project in order to maximize profit, the effectiveness of the approved development options is also considered in relation to the investor. The investor, considering various investment projects to select the best investment option, uses the above equations and can select those projects that will provide sufficient effect at an acceptable level of risk for the investor (Jones, 2010).

The input for the task are:

1. Many sources of investment resources of the territorial-industrial complex.
2. The value of the planned investment resources for each source.
3. Numerous proposed investment projects considered as potential investment objects.
4. Investment volume and performance estimates for each of the potential investment projects.

3.3. Case: Investment projects within the industrial cluster

Using the above scheme, let us solve a specific problem of rational investment in a separate industrial cluster within one year. Investments of €102840 million are planned from the cluster budget. Consideration is given to five investment projects. The amount of the investments in each project and estimated value of the investor's profit from that investment (at the end of the period) are shown in Table 1. It is necessary to determine the amount of funds to be invested rationally in each of the possible projects to maximize the total profit. In this case, we will assume that the profit planned for each project does not depend on the investment in other projects, and the total profit will be equal to the sum of profits received from each project that will be implemented.

Table 1. Input information to solve the problem of allocation of investment resources within a separate industrial cluster (Model 1)

Amount of investments mln. €, (x)	Estimated profit on projects, mln. €				
	f1(x)	f2(x)	f3(x)	f4(x)	f5(x)
20568	10680	5000	7080	8200	4200
41136	18800	10400	14520	16900	10600
61704	31500	14900	22860	31480	18360
82272	40200	20500	36160	44220	20400
102840	50600	45400	48020	51000	25080

Let us construct an economic and mathematical model of this problem. The following notations will be introduced: *xk* – investments in k^{th} project *(k=1,2,3,4,5), f(x)* - profit on projects. Then the total profit will be:

$$Z = \sum_{k=1}^{5} f_k(x_k). \tag{11}$$

Variable *x* is restricted as follows: $\sum_{k=1}^{5} x_k = 51420,$

$$x_k \geq 0,\ k = \overline{1,5}. \tag{12}$$

It is necessary to find the variables $x_1, x_2, \ldots, x_5$, which comply with the limitations (12) and which turn the function (11) to maximum.

Calculations as per the described scheme, result: $Z_{\max} = Z_1^*(102840) =$ €54900 million, when $x_1^* = x_1^*(102840) = 20568$, $x_4^* = x_4^*(82272) = 82272$, that is *X*=(20568, 0, 0, 82272, 0).

Maximum total profit will be equal to €54.9 million provided that €20568 million is allocated for the first project and €82272 million for the fourth project.

Let us now solve the problem of allocating €4728 million of investment across six investment projects (initial figures are given in the Table 2).

Table 2. The input information to solve the problem of allocation of investment resources within a separate industrial cluster (Model 2)

Amount of investments mln. €, (x)	Estimated profit on projects, mln. €					
	f1(x)	f2(x)	f3(x)	f4(x)	f5(x)	f6(x)
945.6	450	270	190	270	136	370
1891.2	906	684	364	630	270	720
2836.8	1290	810	676	944	540	1090
3782.4	1880	1208	900	1260	900	1968
4728	2250	1350	1124	1898	1350	2275

Having carried out calculations using a similar algorithm, we obtain the following result. The maximum profit will be €2418 million with allocation of investment resources of €945.6 million for the first project and €3782.4 million for the sixth project.

Thus, the industrial cluster, as an investor, looks at different options for investing resources in investment projects and selects projects that can maximize the effect when comparing projects. In our opinion, the methodological approach presented is effective for assessing the optimal structure of formation and use of investment resources necessary to meet the investment needs of the industrial cluster (Gitman et. al. 2008). The proposed equations can be used for brief analysis of investment options using computational algorithms, which will allow in the shortest time to calculate alternative options in order to choose the most appropriate.

With the proposed criterion, it is possible to optimize the investment from a number of sources of investment financing (internal funds of companies, funds of the industrial cluster itself, mobilized through banking institutions, long-term and short-term bank loans) in those projects that can maximize the effect. Such method allows to automate the process of allocation of investment resources and eliminate the subjective approach to decision making. In each case, the decision to choose the best investment option using the proposed optimization technique is made by the investor himself.

The investment cluster balance indicators cover all financial resources that are created in the cluster and used for investment purposes during the forecast period. The scorecard includes the estimated cluster investment capacity indicators; estimated investment forecasts of cluster companies; forecast of future investments; the banking sector forecasts for long- and medium-term credit programs in the economy. The use of an investment balance will allow to reflect the investment situation in the industrial cluster in full extent, to identify its internal investment reserves, to characterize the sources of investment resources and the direction of use of cash flows as fully as possible.

Discussion

The performed analysis and the established methodological provisions can be further developed by new calculations of investment efficiency by formal methods of analysis of the effectiveness of real investments by calculating the net present effect (value), the internal rate of return of the project, the profitability index, the coefficient of investment efficiency, etc. Based on the results of the proposed calculations, as well as using investment forecast indicators at the industrial cluster level, it is possible to form a rational investment balance that will include the investment resources of new members of the industrial cluster, as well as the directions of their investment flows. The investment balance is a program that provides investment processes at the industrial cluster level. The cluster's investment balance should include a system of indicators that reflect the cluster's investment capacity, formation of its investment resources and the directions of their use.

The main provisions of the investment policy within the industrial cluster should be: strategic goals of the companies participating in the industrial cluster; the priorities of the integrated cluster investment program; definition of criteria for selection of investment projects and programs, which will be supported by all participants of the industrial cluster in case of equity financing; the scope of the investment program and potential real sources of its financing; the basic elements of the cluster's investment infrastructure and the ways of their further development; the task of intensifying investment cooperation.

Conclusion

Improving the efficiency of investment management at the industrial cluster level involves a comprehensive analysis of investment processes in the country's economy, study of sectoral and territorial structure of investment, classifying specifics of investment in order to identify the main directions of improvement of cluster management processes. Development of the investment balance should be aimed at the following tasks: 1) determination of the investment capacity of the cluster; 2) identification of the total amount of investment resources of the participating companies, which are directed to investment purposes; 3) determination of the total amount of investment

resources aimed at development of production, infrastructure; substantiation of use of revealed total amount of investment resources directed to the cluster system; 4) identification of the internal reserves of the cluster and ensuring their rational use; 5) establishment of trends and patterns of formation of investment resources at the industrial cluster level.

It has been determined that improving the efficiency of cluster investment management is facilitated by refinement of the mathematical support of decision making on the choice of investment options. It is proposed to optimize the use of limited investment resources by stages, including the following steps: identification of potential sources of investment financing and volume of the investment proposal; determination of the amount of investment required for the cluster; determination of the criterion of expediency of financing investment projects; combining investment resources with investment projects according to the accepted criterion; determination of the optimal structure of investment placement. It is proposed to use the Bellman criterion as the criterion of optimization.

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