Improving the Efficiency of Projects of Industrial Cluster Innovative Development Based on Enterprise Architecture Model

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Abstract: Analysis of the impact of architecture model of cluster management on the strategy of its innovative and investment development, ongoing innovation activities, the growth of innovative capacity and effectiveness of development projects due to the appearance of architectural synergy.

Key-Words: industrial cluster architecture, business architecture, IT architecture, cluster development projects, architectural model of development, effectiveness of development projects, architectural synergy.

1 Introduction

Innovative development of industrial cluster requires a specific set of conditions that determine the amount of available resources and mechanisms of their transformation into the final innovative product - a result that confirms the appropriateness of its creation.

The ability of the cluster to innovative development is largely determined by the presence, the current level and future state of its innovative capacity, which in modern conditions is the determining factor of this development.

A peculiar kind of combination of within the boundaries of the cluster competition and cooperation ensure effective use of resources, innovation, simplifies management of innovative projects, increases the efficiency of production and business activities and promotes the formation of a synergistic effect [1]. Building a system of information and knowledge sharing with the use of modern means of communication, it contributes to the development of innovative and productive capacity and exchange of business models. The information infrastructure, based on modern methods and models of information systems development, data, and knowledge exchange, is particularly important for development and growth of the cluster. This infrastructure should support the organizational and economic mechanism of cluster management and mathematical methods and models, on which it relies. Construction and development of such infrastructure is only possible on the basis of an architecture approach and development of cluster architecture [2].

The cluster architecture allows you to create an architectural model for managing all areas of its activity. This model strictly and explicitly converts the strategic goals and objectives of the cluster development and its operation activities into the business architecture and provides its implementation via system architecture resources [3]. The development of such model allows quickly responding to changing economic, organizational, technical factors, both within the cluster and in the external environment, and provides management of cluster resources in the implementation of innovative projects. Quality of enterprise business model affects the results of its operations [4]. Management of enterprise business model is possible only within the framework of the *enterprise architecture* concept, which enables you to create business models and improve them with a change of strategic and tactical models of the enterprise, based on an adequate system architecture.

Architectural model of management is a modern concept, based on the balance of the needs of developing economic objects and the information resources and capabilities of information technology supporting these needs. It involves a process approach to management system, which proved itself in ISO projects, confirmed its effectiveness in the projects of development of enterprise corporate systems. However, the complexity of reengineering activities in the enterprise became evident in such projects. It is needed to support, maintain and execute the developed business model as well as provide service support to it. The rapid development of economic processes in the global economy forces companies to adjust the process based structure of

the business model and to implement innovations ensuring the growth of the innovation potential. The developed portfolio of innovative and investment projects also require significant architectural support, as their implementation is based on the company's resources. Architectural model of management supports processes of business performance management. It bases itself on BPM systems and service architecture.

Construction and subsequent management of the cluster is associated with the need to connect business projects in a specific field of technology, fundamental developments, the modern systems of new products development, as well as information resources that provide support for such projects within one particular industrial infrastructure.

To provide management of a cluster and its production and innovation processes, integrated information systems should be developed, the main task of which is to integrate all business processes of cluster participants. This infrastructure must be based on modern communication technologies that provide information exchange. Such an infrastructure supports architectural model of management of cluster development processes, ie, the architectural model of cluster management is based on its architecture. According to Gartner, the approach to the construction of the architecture should be based on an analysis of company-wide processes of all cluster members and on re-evaluation of their business processes and applications supporting them. The problems of creating an information infrastructure of a cluster, using resources of business performance management systems and building of service architectures are analyzed in detail by the authors in [9]. As a result of such a model a synergy effect appears, which includes in the addition to classical components an architectural synergy. The projects of cluster development are always associated with a series of organizational changes. One of the tools supporting these changes is enterprise architecture. There are two main approaches to organizational change. The first approach involves the reorganization, reengineering processes, and the second - with knowledge management. Enterprise architecture is primarily a knowledge management that will improve the efficiency and transparency of the implementation of key business processes, to ensure continuous monitoring of performance and reliability of management information, exchange of technological information, increase the capitalization and investment attractiveness of the cluster. It is impossible to manage processes of cluster innovation development in modern conditions without the support of an architectural model of management. This management model provides the increase of effectiveness of cluster innovative development projects. The cluster by itself generates an effect of production scope, which is based on an innovative center that stimulates the production of new products and services. The simultaneous production of several types of products, diversification of its activities, which increases the economic resilience of the cluster and its members, is also an advantage of a cluster.

2 Innovative development of the cluster and mechanisms to ensure

2.1 Innovative potential of industrial cluster as the dominant factor of its development

When analyzing the ability of an industrial cluster to innovation development it is necessary to deal with the economic aspects, which determine or limit its "innovative power". This seems to be the reason that the economic content of the "innovative capacity" concept traditionally comes out within the resource approach. Resource capacity, considered as a component of the innovative capacity, represents a set of concrete economic resources for the production of innovative products [5].

It is an objective resource component which is the basis of forming innovative capacity of the industrial cluster. It includes components having different functional purposes: intellectual, logistical, informational, financial, labor and other resources.

The most important element of the objective resource component are information resources. They represent a set of documents, knowledge, information, application processes, management regulations, etc. and information and communication technologies that provide access to information resources. This set forms the information infrastructure of the cluster.

Information resources play a huge role in the cluster management; they change over the material and other resources and factors from latent to active condition.

All other types of resources have a significant impact on the choice of innovative projects content in accordance with the needs of operation and development of the cluster. However, the management of innovation activities should be carried out on the basis of the information model.

It is pointless to analyze the innovative capacity of industrial cluster without evaluating the possibility of its practical implementation. In this,

one of the most important resources are organization and management resources, i.e. management's ability to mobilize and organize its potential in a single system in order to obtain a synergistic effect. Organizational and managerial component is formed in the process of developing a business model and is a major component of the architectural model of management.

In the industrial cluster innovations are spread via network of relationships in the general economic environment [6], which facilitate the combination of factors of production and provide conductivity of innovative environment. The architectural model of management allows maintaining the information, knowledge and skills flow, increasing the efficiency of innovation processes.

2.2 Strategy of innovative development of industrial cluster

A targeted innovation process in an industrial cluster is a necessary element and tool of its economic development. This process should take into account the specificity of the cluster and its environment. We are not talking about any particular specific innovation, but about strategy based continuous innovation activities. Only that is amenable to the strategic management [7].

Innovation strategy can be regarded as a plan of innovations in the sense that it refers to the entire duration of the innovation from the search for new scientific and technical solutions through the production and marketing to the use of new technology, represents the main points of monitoring and intervention based on the results of market research, sets the pace of production renovation and the way of finding required intellectual labor products. It requires constant attention of managers on selected milestones and binds to manipulate planed resources; it represents management as an integral and continuous process, the implementation of which is not possible without a strong information-technological and methodological support that can be provided by *architecture model of management*.

The theory of strategic management, in general, and of strategic management of innovative development, in particular, is a relatively new trend in economic science, formed in the mid-twentieth century. Its appearance is due to the practical need for new techniques and methods of making management decisions in an unstable economic dynamics. Strategic management is based on the situational approach in which a business entity, in our case the industrial cluster is regarded as an "open" system. Successful innovative activities of a cluster depend on how quickly and easily it adapts to changes in the external environment. This adaptation requires a flexible management structure, which is a component of the *business architecture*. Its organizational mechanism is adapted not only to the development of solutions, but also to the control of already existing solutions and provides flexibility in the allocation of resources.

Application of the methods of strategic management allows dividing the process of innovative development of the cluster into two stages:

• strategic planning stage, that is the development of strategies, based on which a *business model* of innovation activities can be developed;

• stage of implementation of the strategy over time to reflect changes in economic environment, and this is an *architecture model of management* of innovation processes.

To make a reasonable choice of development strategy the tools of modern strategic management are used: SWOT-analysis, value chain analysis, cost analysis, assessment of competitiveness.

SWOT-analysis gives a description of the internal state of the economic system, studies its strengths and weaknesses, and assesses opportunities and threats in the external environment. Cost analysis allows evaluating the effectiveness of the implementation of certain activities, compare the costs with the costs of competitors, and decide which activities require for rationalization. Value chain analysis identifies the main positive features of the system, and effective management based on its result allows using them as a competitive advantage.

The basic principle of the development of strategy of the industrial cluster innovative development is that it should meet the following criteria:

• effectiveness of the strategy used, possibility of its subsequent correcting;

• adequacy of the environment features for the innovative capacity of the cluster;

• degree of operational excellence.

The assessment of chosen strategy being in accordance with these criteria, as well as the analysis and comparison of the various options of strategy of cluster innovative development requires a strong information and methodological support that is fully assured in the architecture model of cluster management. Indeed, the basic principle of synergistic economics [8] is maximization of utility and profit of business entities, primarily due to the concerted action and coordination of interests. This leads to mutual focal and adaptation processes, such

as arbitration, regulation of prices, quantities of produced and delivered goods through the conclusion and renegotiation of contracts, i.e., coordination of individual actions as long as they lead to an equilibrium state and provide well-balanced economic situation.

2.3 Organizational-economic controlling mechanism of innovative development of the cluster

The basic condition for success of cluster initiatives, mobilization and management of its innovative capacity, realization of functioning and development strategy is the formation of organizational-economic mechanism of cluster management [9]. Its main objective is to create a system of relationships between cluster partners contributing to the realization of its strategy, including the opposition of negative factors, operative adjustments, response to changing external conditions and internal environment of the cluster.

Organizational-economic mechanism of management has to ensure the use of objective economic laws, patterns and resources to achieve the goals. It includes a set of system elements that define the processes of direct and indirect effects on the conditions of formation and development of management object and ensuring the realization of cooperative interactions of cluster partners in order to implement its strategy. These processes are specified in the management methods, technologies and approaches.

In circumstances where a variety of business entities of various forms of ownership, each of which is governed by its own economic interests, act within an industrial cluster, the best option of management belongs to the tools of indirect effect (coordination, regulation, promotion), allowing no direct intervention to create favorable conditions for the development of innovative capacity and its realization. The knowledge of traditional management practices is not enough, an integrated approach to management is needed, and it should be based on an *architecture model of management*.

Organizational-economic mechanism of industrial cluster management and creation of information infrastructure supporting management processes act as a basic component of the *cluster architecture*.

Organizational-economic mechanism of cluster management relies on a number of management methods and models: institutional, economic, mathematical, administrative, legal, providing the infrastructure of information support, which is based on the information and analytical systems, knowledge bases, databases, and other architecture solutions. Information infrastructure provides the creation of cluster development strategy, mechanisms of cooperation of cluster participants, resource management, planning, contracting, operational solution of management tactical issues, project management, monitoring and evaluation of economic efficiency. The major problem here is the organization of communication processes and modeling of data exchange in the integrated information environment [10].

The development and subsequent management of the cluster is associated with the need to unite manufacturing business projects in a specific technological area, the fundamental design of the system and modern design of new products and manufacturing of these products, as well as information resources that provide support for these projects under one particular infrastructure [11].

The union of knowledge, information and technology sharing cycles under a single management system should build institutional structures supporting the future cluster, which combines in its organization a few new industries providing innovative development.

To manage a cluster as well as its production and innovation processes integrated information system should be developed, the main task of which is to integrate all business processes of cluster participants, to build an information infrastructure of IT solutions on their common principles and inclusion, based on management processes of participants. This infrastructure should be based on modern communication technologies ensuring information exchange. The remote control of work and development projects in the structure of the cluster will provide timely and proficient solutions of organizational, scientific, technological, industrial, economic and governance issues. Industrial cluster to ensure its development should become a producer of integrated practice-oriented knowledge, which allows determining the priority areas of investments in innovative projects.

3 Main directions of evaluation of cluster activity efficiency based on enterprise architecture model

3.1 Evaluating the efficiency of investment projects

Evaluating the efficiency of development projects is based on standard criteria for investment analysis, based on discounting: the net present value of the project (*NPV*); internal rate of return of the project

(*IRR*); payback period based on discounted estimates (*DPP*); project profitability index (*PI*). Methods for calculating these indices are widely known, but the indicators themselves, with different nature, may contradict each other, i.e. a project adopted in accordance with one criterion may be not with regard to economic considerations of another criterion [12]. In addition, some factors allow obtaining absolute evaluation calculations, but others give relative calculations [13].

Because of the specificity of innovation projects, not all of the classical criteria can be used to analyze the efficiency of financing innovation. Analysis of numerous studies on the problem of evaluating the efficiency of innovations has shown that in most cases the authors' attention is focused on methodologies for assessing the economic efficiency of investment projects [14]. However, despite the common methodology for assessing the cost-efficiency of such projects, innovative projects have a number of specific characteristics that must be considered in the assessment of their efficiency. Most often, implementation of innovations is aimed at significant changes of indicators of economic activity of cluster or individual structures, which requires significant investments.

Some experts, such as O.N. Zemskova [15], offer other indicators of investment analysis, which are of some interest, because consider the fact that some costly innovative projects in the cluster cannot always be financed from its own funds.

These indicators often include the debt capital and its costs; these are: the degree of internal financing of the upfront investment and the annualized net present value (*ANPV*), as well as *IRR* and *DPP*, calculated on the basis of *ANPV*.

The upfront investment required at the initial stage of the innovation project is the most risky and less liquid one. In this regard, the share of project initiator in the upfront investment acts for other investors as an indicator of seriousness of his intentions and validity assessment of prospects for the development of commercial innovation. The second indicator is used to control the absence of the shortage of available funds and allows concluding about the financial viability of the project.

The net present value of the project is calculated for the whole period of its implementation, based on the annual net flows of the project, excluding its financing scheme. Traditionally, the current index value of the project is counted according to the following formula:

$$NPV = \sum_{t=1}^{T}(R_t - Z_t)\frac{1}{(1+r)} \quad (1)$$

where R_t - cash inflow in year t;

Z_t - cash outflow year t;

r - the discount rate;

T - project life in years.

The project is deemed efficient if $NPV > 0$.

This approach to the calculation of NPV does not account the likelihood of financing deficit and debt financing. For the control of financing deficit the *ANPV* indicator can be used. In contrast to the traditional *NPV*, calculated on the basis of cash flows from investing and current activities, the annualized net present value is based on three types of flows: investment, current and fiscal. So it is necessary to have in the project management documentation a plan for its financing, including the credit plan.

Annualized net present value is calculated by the formula:

$$ANPV = -(F_{int} + D) + \sum_{t=1}^{T}\frac{CF_t^a}{(1+r)^t} \quad (2)$$

where F_{int} – planned financing investments in the project from its internal funds in the starting year;

D – debt attracted to cover the deficit in upfront investments;

CF_t^a– annualized net cash flows in the year t, calculated not only on the basis of project cash flows, but also on the cost of servicing loans taken to finance the project.

If $NPV > ANPV$ (with the proviso that $NPV > 0$), project may be called efficient; moreover, the efficiency can be increased in real terms of debt financing. Opposite inequality shows that debt funding may negatively affect the efficiency of the project. If both indicators are equal, the efficiency of the project does not depend on the funding scheme.

Possible differences between *NPV* and *ANPV* are associated with characteristics of the cash flow. In the initial stages of most projects cash flow is negative due to the lack of return, moreover the debt capital requires maintenance costs. As a result, the net cash flow at the end of the project is less than the cash flow into account when calculating *NPV*. Thus, the indicator *ANPV* may be a reliable tool for evaluating the effectiveness of debt funds.

3.2 Evaluating the efficiency of innovative projects

Analysis of the continuous innovation activities in the cluster leads to the conclusion that within the same time period innovative projects are at various

stages of implementation and may involve several participants. In this case, the use of traditional methods of project analysis becomes impossible or insufficient - both positive and negative cash flows of individual projects and existing operations can mutually neutralize each other and distort the overall evaluation of the efficiency of using debt and internal resources.

It is therefore necessary, as rightly said by V.I. Barilenko [16] to distinguish the concept of "analysis of innovation projects" and "analysis of innovation activity during the reporting period". Many of the characteristics of innovation activity allow using them for analysis of indicators and standard analytical procedures used in the traditional analysis of economic activities, such as evaluating the efficiency of using debt and internal funds.

Features of the innovation activity of industrial cluster and its funding processes are so large that it requires the development and use of special techniques and indicators [17]. Innovation development of modern industrial clusters, requiring significant costs of raising and maintenance of necessary funding, makes use of particular importance to assess the effectiveness of innovation indicators of economic value added *EVA*.

The essence of the *EVA* concept is logically linked to the objectives of the analysis of debt funds in innovation activity as it is that the whole company is regarded as a kind of investment project with an initial capital, which requires the involvement of certain costs. The difference between yields subjected to innovation and the cost of capital invested in it, determines the amount of economic value added.

M.P. Apin offers to calculate the economic value in different ways [18]:

$$EVA = NP - (WACC * IC) = \left(\frac{NP}{IC} - WACC\right) * IC = (ROI - WACC) * IC \quad (3)$$

where *IC* - invested in venture capital;
WACC - weighted average cost of capital;
NP - net profit;
ROI - return on invested capital.

One of the ways to evaluate the market value of the company is the addition of the net assets of the balance sheet and the amount of *EVA* given to this point in time. In accordance to this the market value of the enterprise may exceed the carrying value of net assets or be lower than it, depending on the size of future amount of *EVA*.

This implies three possible alternatives of an average weighted price of the invested capital in innovative enterprise and its profitability, and as consequence in the *EVA* index:

1) *EVA* = 0 for *ROI* = *WACC*. Return on invested capital is equal to the cost of raising this capital and the market value of the company's net assets is identical to simply balance. In such a situation there is no market gain on investments in innovation development of the enterprise;

2) *EVA* > 0 for *ROI* > *WACC*. Excess margin investment cost of financing means increase in the market value of the enterprise over the carrying value of net assets at the expense of innovation. This situation stimulates additional investment in innovation development;

3) *EVA* < 0 for *ROI* < *WACC*. *EVA* negative value indicates a decrease in the market value of the enterprise, as the cost of capital is greater than its benefits. In this case, the owners lose their invested funds, which encourages them to make a decision about moving their capital to another, more efficient project.

In the context of existing industrial cluster the main way to increase *EVA* is the development and implementation of effective innovation projects. Since the implementation of such projects, as a rule, is based on debt financing, it is logical to propose a methodology to evaluate the efficiency of the debt funding using the relative index of debt payoff. The proposed indicator is advisable to rely on the base of created as a result of innovation enterprise economic value added, as it is *EVA* that reflects the value created over the cost of raising all the capital invested.

Profitability of innovation cannot be ensured by increasing expenses on their implementation - it usually means a simple waste of resources for increasingly obsolescent projects. According to experts [19], the way out can be found not in increasing the expenses, but improving the efficiency of base costs. This will increase the return on investment in innovation, improving the *ROI* indicator.

4 Conclusion

The availability of multiple criteria for evaluating the effectiveness of projects of cluster innovative development helps to efficiently finance and expend the resources, as well as to provide high quality management decisions and their information support in a constantly changing economic environment as part of the cluster architecture [20]. Any innovative and investment project, regardless of its economic importance for the cluster must contain a social effect, for example, the creation of additional job

positions, cleaner production, etc. Therefore, a portfolio of development projects and justification of its investment support size should be based on a balanced business model of the cluster [21], performance and change of which is supported by the system architecture.

Thus, the *architecture model* of cluster management based on a single business model allows you to consolidate all of its business processes: production, innovation, investment, research, education, social issues and others. It provides control of these processes, taking into account the strategic and tactical problems of cluster enterprises, reallocation of resources and adjustment of the business model, taking into account external and internal economic factors affecting the process of functioning of the cluster. It also allows you to quickly adapt the organizational-economic mechanism of this model and is based on IT architecture. All this cannot be done within the framework of traditional approaches to the management of large industrial structures. Architecture model of management combines the best qualities of both economic and administrative management models, uses the mechanisms of the functional model and is based on the management process model. It also provides the architectural and other synergies [22] in assessing the effectiveness of development projects in the cluster.

In economic practice the implementation of architectural management model requires significant infrastructure changes and a certain level of corporate maturity of the enterprise. The complexity of cluster information processes currently don't allow you to fully evaluate the effectiveness of this model in an experimental way, any statistical information is simply not available. However, based on the estimates of experts in the field of economic analysis of the results of projects of large corporate systems implementation, which form the basis of the information infrastructure of the cluster, it can be concluded that these estimates are correct for the cluster structures as well. Among these are a significant increase in productivity, an increase of working capital turnover, a reduction in inventories, and the overall growth of investment attractiveness of the cluster, and increased competitiveness. Any quantitative estimates in this case do not matter, since for each industrial cluster they will be different. But the architectural management model is based on much more important tools in comparison with the possibilities of the corporate information systems. We talk about powerful tools of business performance management - BPM system, as mentioned earlier. BPM enables enterprises to define strategic goals and then evaluate the effectiveness of their activities in relation to these goals and to manage the process of achieving them. In this case, the key BPM processes are related to the implementation of the cluster strategy and its members and include financial and operational planning, consolidation and reporting, modeling, analysis and monitoring of key performance indicators.

With regard to the increase of the efficiency of cluster development projects, in addition to discussed traditional indicators of investment appraisal, we can confidently assert that the architectural model of management of these processes can significantly reduce the risks of project management, but the problem of risk assessing is not a subject of this study.

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