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DEVELOPMENT OF AN INTEGRATION-ANALYTICAL METHOD FOR THE INITIATION OF CONSTRUCTION PROJECTS OF INDUSTRIAL OBJECTS

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Досліджено процеси управління ініціацією проектів будівництва промислових об'єктів. Розглянуті специфічні риси проектів будівництва промислових об'єктів, які впливають на структуру життєвого циклу проекту, графік його фінансування та визначаються технологічними параметрами нового будівельного об'єкту. Визначено, що сучасний інструментарій управління процесами ініціації проектів не здатен повною мірою забезпечити передпроектний аналіз альтернативних варіантів проектів будівництва промислових об'єктів. Це обґрунтовує необхідність створення комплексного методу аналізу проектів будівництва промислових об'єктів на етапі ініціації, який буде враховувати специфіку проектів та задовольняти потреби ініціаторів.

Розроблено інтеграційно-аналітичний метод ініціації проектів будівництва промислових об'єктів, який має комплексний характер, враховує специфіку життєвого циклу даних проектів, високий рівень інноваційності та необхідність у специфічних ресурсах. Запропонований метод має покрокову процедуру виконання, що забезпечує ітераційний процес аналізу проектів будівництва промислових об'єктів, та дозволяє прийняти обґрунтоване рішення про відмову від реалізації проекту, не виконуючи усіх кроків методу. Це, за умови недоцільності реалізації проектів будівництва промислових об'єктів, значною мірою скорочує час необхідний для передпроектного аналізу альтернатив, та обсяг витрачених коштів.

Перевагою реалізації інтеграційно-аналітичного методу ініціації проектів будівництва промислових об'єктів є економія часу та ресурсів, необхідних для управління процесами ініціації проектів будівництва промислових об'єктів. Це досягається завдяки інтеграції та адаптації існуючого аналітичного інструментарію у комплексний метод шляхом виключення випадків подвійного розгляду аналогічних показників, та таких, які на даному етапі не мають ключового значення. Та завдяки формуванню процедури реалізації методу, яка відповідає специфічному життєвому циклу проектів будівництва промислових об'єктів

Ключові слова: промисловий об'єкт, життєвий цикл проекту, специфічні ресурси, інноваційність

1. Introduction

It is a complex and large-scale task to obtain sufficiently reliable qualitative and quantitative forecast of estimates for the implementation of a project to construct industrial objects. First of all, it is related to the need in a large volume of capital investments to provide specific resources and a necessary amount and variety of unified resources for a construction project. Second, due to the need to obtain a certain value of investments effectiveness in the absence of a single indicator for the probability of reimbursement of expenses.

Modern conditions for the implementation of projects related to construction of industrial objects change very rapidly due to instability of the economic situation; therefore, it is appropriate to base rules for estimation of a quality of investment projects on the investor's policy. That is, the basis of a decision-making process on the initiation of a project is a comprehensive assessment of the potential of a future industrial enterprise in terms of both business operation and production process, that is, the effectiveness of future technology. The first step in the procedure for the selection of the most effective solution in the process of initiation of a project is to form an array of indicators for each phase of PCIO initiation. Indicators will be the basis for a decision on feasibility of project implementation.

At present, tools and methods for making managerial decisions are usually narrow-minded and focused on analysis of a separate project component, whether it is competitiveness of a new product, or economic efficiency of an industrial object, etc. Such detailed specialization in one direction provides high-quality and cost-effective analysis for each project area. Taking into consideration a large scale and complexity of PCIO, a cost of such an analysis at the initiation stage amount to about half of a total project investment. However, it is not correct to spend such significant funds for activities that may not bring in results in the case of refusal to implement PCIO. This fact indicates the low feasibility of performing such a thorough analysis of PCIO at the stage of its initiation.

That is, there is a contradiction between a need for an in-depth analysis of PCIO at the initial stage and the imperfection of means to achieve this objective in the form of integrated analytical methods, which take into consideration the specificity of PCIO.

Thus, the issue of ensuring a selection process of the most promising PCIOs at the stage of initiation based on appropriate scientific tools is relevant both in applied and theoretical aspects. It needs scientific consideration and revision.

2. Literature review and problem statement

An analysis of modern tools used for pre-investment analysis of alternative project variants showed that bases of models and methods are different components of a project or combinations of components. For example, paper [1] proposed a method, which makes it difficult to predict time parameters of realization of a construction project of an industrial object without taking into consideration time required for a purchase of equipment, its installation, testing and operation. The approach does not make it possible to establish accurate forecast efficiency indicators for an entire project, and therefore this methodology cannot fully meet needs of PCIO investors.

The method presented in work [2] allows running an analysis of a construction project to select the most effective system of financing. That is, the methods provide analysis of all possible sources of funding for a construction project and options for their ratio to ensure optimum cash flow necessary to meet project needs. Since the base of the approach is CRM, determination of a size of required investments and possible options for a ratio of funding sources, we can state that the technique is appropriate at the stage of project planning. In addition, such an analysis is large-scale and complex, and therefore it has a high cost, which makes its use unjustified from an economic point of view at the stage of initiation of PCIO.

Authors of paper [3] proposed a method for planning the cost of construction-and-energy projects, which takes into consideration a change in a cost of resources over time, investment and time limitations of a project. The method takes into consideration dynamic changes in the environment of a project, and makes possible to predict the most accurate cost of a construction project in a long run. However, a use of the method for analysis of projects that have a lifetime of up to one year is not appropriate, because a base of the method of planning of a cost of construction-and-energy projects is a procedure of reduction. A change in a basic indicator of it occurs once a year. Consequently, the method is not relevant for PCIO analysis, since realization of such projects takes up to 1 year.

During the analysis of a project, authors of study [4] suggested, first of all, to identify and assess risks of a construction project, to compare risks by a level of criticality, and to decide on appropriateness of realization of a construction project based on results obtained. Authors of [4] proposed to apply this approach primarily to “green building” projects. Such specialization justifies inclusion of various estimation procedures that are not applicable to industrial objects construction projects to the procedure of risk analysis of a project. In addition, the method of assessment of feasibility of a project based on its riskiness does not provide a full amount of necessary information for making an adequate management decision. This demands more attention to development of complex methods for assessment of projects at the initiation stage from the scientific community.

Authors of the study presented in paper [5] proposed a mechanism for structuring of a decision-making process in construction projects in the presence of constraints, such as resource shortages or specific project limitations and organizational limitations. The basis of the mechanism is an analysis of partner relations between stakeholders of a project, and a change in an additional cost of a construction project. Such an approach is appropriate for implementation of construction projects of low innovation level. Since PCIOs are highly innovative projects, this method of estimation of the predictive cost of a project is not appropriate. In addition, the base of PCIO is an offer of a partner-supplier of specific equipment.

In work [6], authors conducted a study of the 50-year construction and operation of an American bridge. The result of the study was the discovery that a use of all opportunities created by a project and an increase in benefits of a project requires involvement of many categories of stakeholders. They discovered also that interested parties are more involved in a project when they are proud of it. They determined that it may take a long time for some project-related capabilities before their application and achievement of appropriate benefits. These results are important in the view of authors of an article, since the specificity of PCIO is largely the same as in the project studied in the work. PCIOs have a large number of stakeholders, and a significant part of the success of a project depends on performance of their activities. Results of a project have a long-term use.

Authors discussed management of relations with suppliers and/or subcontractors in construction projects in paper [7], they found that these relationships are critical due to the additional dependence of completion of work on them. However, it is unclear what factors influence such relationships in construction projects. Data collected by the authors of the study demonstrated how different aspects of relationships with suppliers and/or subcontractors can affect project outcomes. In study [8], authors noted that the competence of human resources of a project is a critical indicator, which needs analysis at the stage of project initiation. Because their value depends on achievement of the most part of results of a construction project.

Thus, we should note that there are many studies focused on development and improvement of methods of analysis of construction projects. Their results give possibility to decide on feasibility of implementation of construction projects. However, bases of all the methods are various aspects of project analysis, such as time of project implementation, its cost, human and other resources availability, etc. PCIOs are complex projects, and therefore, they require a comprehensive and thorough analysis, that is, integration of analyzed methods and tools. In addition, the method of PCIO analysis at the initiation stage should take into consideration the fact that the primary factor is an offer of suppliers of specific equipment, which will ensure a technological process of production further. That is why the issue of development of a complex integration-analytical method for initiation of PCIO is relevant. It requires scientific consideration and revision.

3. The aim and objectives of the study

The objective of the study is to develop an integration-analytical method for initiation of construction projects for industrial objects. It would make it possible to bring down resource and time expenditures required for an analysis of alternatives to PCIO at the stage of project initiation.

We need to solve the following tasks to achieve the objective:

– development of a mechanism for formalization of the idea of PCIO as an investment object;

– development of a procedure for analysis of the market for implementation of PCIO innovative products;

– improvement of the method for analysis of competitive advantages of PCIO innovative product;

– improvement of the model of selection of a supplier of specific equipment for PCIO implementation.

4. Materials and methods to study the processes of complex multicriteria analysis of PCIO at the stage of initiation

The untypical architecture of the initiation phase of PCIO requires an integrated approach to its realization. That is, a use of a set of methods of investment, marketing and innovative nature. It is expedient to structure them according to stages of a conceptual model of the initiation phase of PCIO initiation presented in paper [9]. There is a modified express-estimate based on sectoral coefficients applied at the stage of formalization of PCIO idea. There is a comparative step-by-step analysis according to characteristics of the market, a product of PCIO, consumers and competitors adapted to the specifics of PCIO at the stage of the analysis of the market for implementation of a product of a new industrial object. It includes the LONGPEST analysis. There is a procedure of assessment of the innovative potential of PCIO based on the model of product competitiveness applied in the analysis of competitive advantages of a product of a new industrial object. Selection of a supplier of specific equipment for an industrial object goes according to a supplier choice model based on a fuzzy logical method, which uses compositional aggregation rules for description of alternatives with information on advantages of a decision maker. The final step of the integration and analytical method of initiation of projects for construction of industrial objects is a procedure of making a decision on acceptance/refusal of realization of PCIO.

4. 1. Development of a mechanism to formalize the idea of PCIO as an investment object

The first stage of the integration-analytical method of initiation of projects of construction of industrial objects is formalization of the idea of PCIO as an investment object. At this step, we define the following: investment attractiveness of industrial activities for PCIO realization.

Authors of papers [10, 11] proposed to carry out forecasting of a market situation for the choice of main directions of a strategy of investment activity and formation of an investment portfolio of an enterprise. But this process is rather large-scale, high costly, descriptive, little formalized and, in most cases, subjective. Therefore, in order to determine investment attractiveness of PCIO industry, we propose to use a modified express-estimate based on the industry coefficients method.

The method of sectoral coefficients refers to the comparative approach of assessment of company value in the classic version. It represents a combination of two following methods: companies-analogues and transactions. A base of calculations are multipliers, i. e. coefficients, which characterize the dependence of the market value of companies-analogues on the main indicators of an enterprise (revenue, net profit, etc.). Here, the main indicators are:

1) Revenue (Sales, S), a.u.;

2) Net profit (Earnings, E), a.u.;

3) Company Value (Enterprise Value, EV) is an analytical indicator, which is an estimate of a company's value taking into consideration all sources of its financing such as debt obligations, preferred and ordinary shares and a share of external owners. The advantage of this indicator is that it takes into consideration company's obligations in terms of its short-term and long-term debts. The lower the value of the indicator is, the higher is the return on the invested capital.

We can calculate EV as:

$$EV=MC+ND+MI, \tag{1}$$

where MC (Market Capitalization) is the market capitalization, a.u.; ND (Net Debt) is the net debt, a.u., MI (Minority Interest) is the cost of shares owned by external owners in subsidiaries of a company, it is not part of the controlling share, a.u.

In turn, we can calculate MC and ND by formulas (2), (3):

$$MC=SP\times SO, \tag{2}$$

where SP (Share Price) is the market value of a share, a.u.; SO (Shares Outstanding) is the number of shares in circulation.

$$ND=STD+LTD-CCE, \tag{3}$$

where STD (Short Term Debt) is the short-term debt, a.u.; LTD (Long Term Debt) is the long-term debt, a.u.; CCE (Cash & Cash Equivalents) are cash and cash equivalents, a.u.

4) Earnings before deduction of interest, taxes, depreciation and amortization ($EBITDA$) shows a financial result of a company, excluding an effect of a structure of capital (that is, an interest paid on borrowed funds), tax rates and amortization policy of an organization. The indicator is useful for comparison of enterprises that are in one industry, but have a different capital structure. Investors focus on $EBITDA$ as on an indicator of the expected return on their investments. We can calculate $EBITDA$:

$$EBITDA=P(L)BT+(PP+A), \tag{4}$$

where $P(L)BT$ (Profit (loss) before taxation) is the profit (loss) before taxation, a.u.; PP (Percentage to be paid) are the compulsory interest payments, a.u.; A (Amortization of fixed and intangible assets) are the amortization charges from fixed assets and intangible assets, a.u.

Application of the industry coefficient method for assessment of future business is complicated in a pure form because of lack of a necessary information base. However, we can use its basic principles for express assessment of industry's approximate attractiveness in order to determine its investment potential. Conduction of a comparative analysis of results of a rapid analysis of several industries will determine a technological orientation of PCIO from the position of the forecast of the highest investment effect. In this perspective, the express assessment by sectoral coefficients will include the following main stages (Fig. 1):

– identification of the industry;

– selection of analogue companies;

– identification of factors of growth of value inherent in the industry;

– determination of an average industry value.

A quality of a sample of analogue companies determines accuracy of estimation of the investment potential of the industry by the indicated method largely. A sample should include about 5–10 domestic analogue companies, as cost coefficients of foreign companies reflect a level of investment risk differently from the Ukrainian level and another stage of a life cycle of the industry.

The implementation of the express method requires definition of a list of factors that affect a value of analogue companies in a particular industry. To do this, we need to study marketing research materials, analytical reviews, and to collect the following indicators of company's multipliers: a ratio of the market value of a business (*EV*) to the reporting date to earnings (*S*) and EBITDA on the previous reporting dates and forecast date.

Since marketing research and analytical reviews may not be sufficient (in particular, it is not possible to determine why cost coefficients of any company are higher than others) for a full analysis, it is advisable to calculate the main financial indicators of analogues based on them, namely:

– a revenue (*S*) for each year

$$S=EV/(EV/S), \quad (5)$$

– a profit before deduction of interest, taxes and amortization (*EBITDA*) for each year

$$EBITDA=EV/(EV/EBITDA), \quad (6)$$

– *EBITDA* growth rate as a ratio of a value for the next period to the previous one deducting 100 %.

We can rank analogue companies by "Cost/*EBITDA*" multiplier and construct a trifactor scoring model on the basis of the obtained financial indicators. Table 1 presents the template of a model.

Table 1

Template of a scoring model to rank the industry's cost coefficients

Company	Rank by *EV*/*EBITDA* multiplier in *T*–1, %	Revenue (*S*) y *T*–1, ths. a.u.	*EBITDA* growth by *T*–1, %	Forecast of *EBITDA* growth by *T*, %
1	–	–	–	–
2	–	–	–	–
...	–	–	–	–
N	–	–	–	–
Average per industry	–	–	–	–

We can determine the most attractive sector of investment placement based on the comparison of indicators of scoring models of different industries. We also can identify potential competitors and establish a forecast level of profitability of an enterprise to ensure its competitiveness, and hence the expediency of PCIO realization.

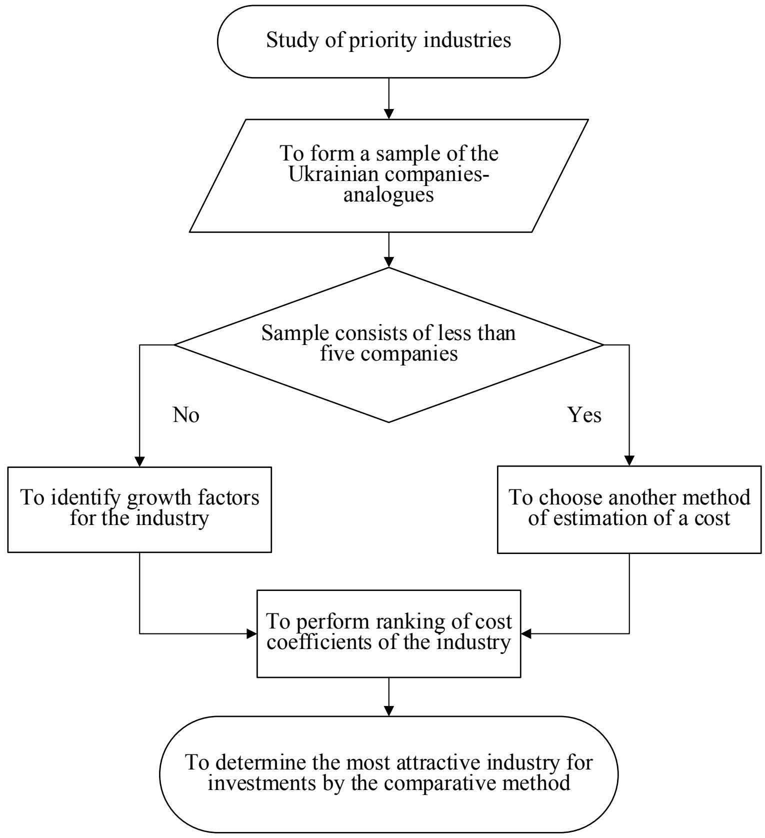

Fig. 1. Scheme of the express estimate of investment attractiveness of the industry

4. 2. Development of a procedure for analysis of a sales market for a new industrial object

Making a decision on the initiation of PCIO requires to carry out a forecast analysis of product's realization of a new industrial object based on market monitoring. There is a large number of indicators, by which we can analyze trends and build trends in market processes. However, a detailed analysis of all indicators is not feasible for the analysis of the market environment for PCIO realization, since a large number of indicators for this analysis are long-term, high-value and complex. Therefore, we propose to apply a step-by-step comparative analysis of aggregate indicators of the market environment for PCIO realization. Table 2 gives the scheme of market analysis.

Let us consider these indicators in more detail. The first indicator of market analysis for a new product is profitability of a selected market segment. Of course, sales profitability is individual for each individual company and depends on a cost of production and on a price of its sale. For a new industrial object, we can use the ratio of a product price to its cost as an indicator for the analysis of profitability of a selected market segment. We denote it as *p*. We can calculate the ratio by formula (7):

$$p=c/pc, \quad (7)$$

where *c* is a unit price, a.u., *pc* is a cost per unit of a product for a new industrial object, a.u.

If we use the maximum market value of a unit of a product for calculation, then this ratio reflects the maximum level of profitability of a segment for a given industrial object. The minimum level of profitability for an industrial object is one, that is, a price of sales is equal to its cost. If the calculated value for PCIO is $p<1$, then the output of a new product on the market is not expedient, since it will bring the corresponding losses. It is a known fact that the higher a rate of return, the better for an industrial object.

However, at the first step of the market analysis, it is also advisable to determine which rate of return is acceptable for a new industrial object. That is to calculate p_{opt}, which will show a level of profitability of a new enterprise to ensure successful operation.

We propose to use this indicator as the basis for further market analysis, as it is the main characteristic of results of enterprise operation. It is expedient to consider the rate of return in dynamics.

That is, we must take into consideration that the indicator may vary in dependence on the stage of realization of a project of construction of a new industrial object and stages of life cycles of a new enterprise and an innovation product.

The indicator of a growth rate of a segment shows dynamics of a change in a size of a market segment over time. The growth rate of a market segment is closely related to a life cycle of a product segment of the market and a degree of innovation of a new product of an industrial object. Thus, if the considered existing products of the market segment are at the stage of implementation, then we can state that the market has high growth rates, and therefore there is potential for the sale of new products. If products of the market segment are in the stage of maturity, that is, the maximum seizure of the market segment, then the output of a new product on the market will require high additional costs. However, if segment products are in a downturn, then growth rates of the market segment are absent or even have a negative tendency. Therefore, it is expedient to put on the market goods that have a significant innovative component only.

Thus, we can state that strategies for introducing a new innovative product to the market with varying degrees of innovation differ depending on the stage of a life cycle of the market segment. Fig. 3 shows this.

We can determine the stage of the life cycle of a market segment at a particular moment by the analysis of a magnitude of a difference between the maximum capacity of a market segment ES and a size of an offer of competitors K at different times. The formula for calculation of the difference has the form (8):

$$\Delta ES_t = ES_t - \sum_{i=1}^{p} Kk_t, \qquad (8)$$

where ES_t is the capacity of the market segment at t time, ths. prod. units, K is the capacity of the competitive market segment k at t time, ths. prod. units, p is the number of competitors.

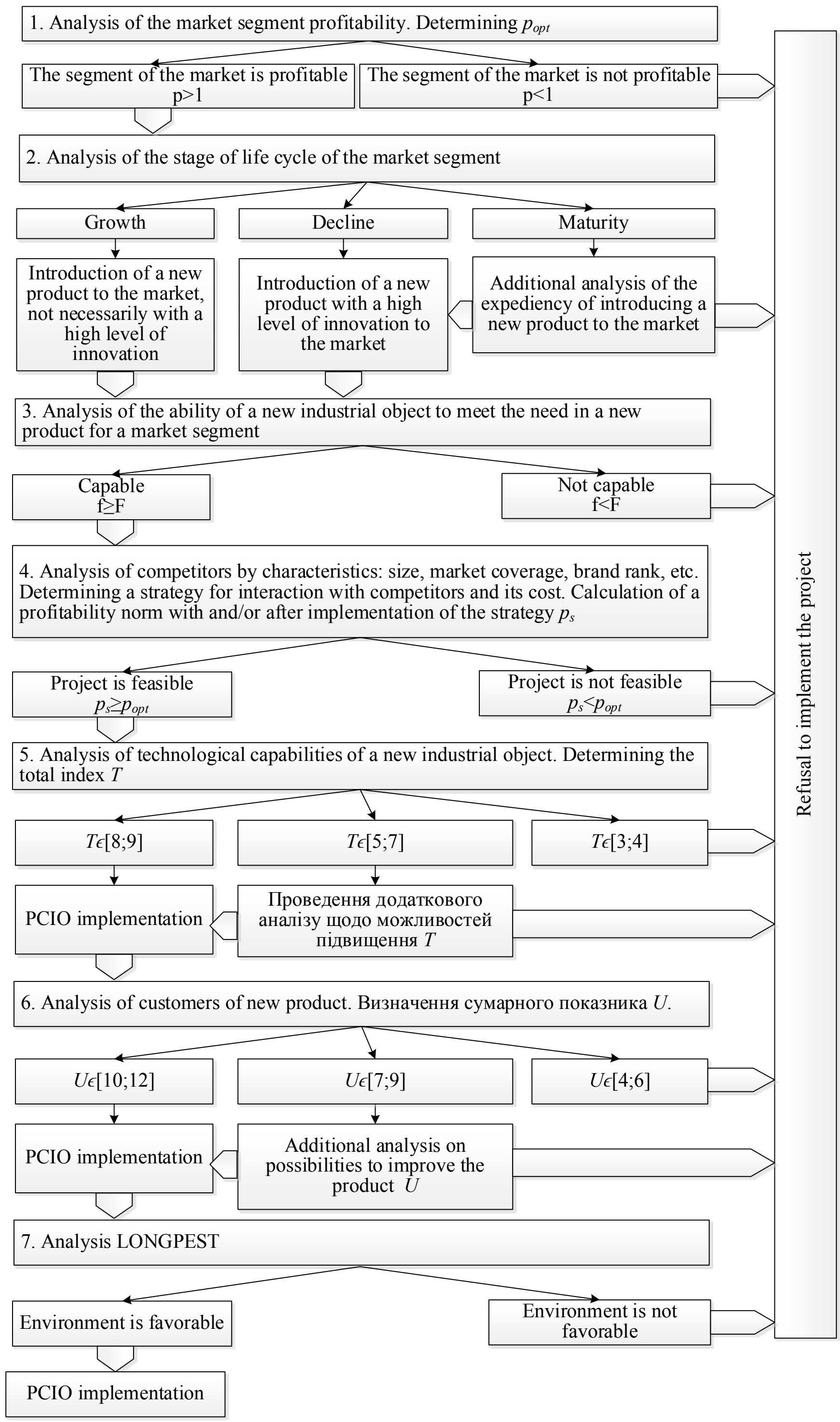

Fig. 2. Scheme of analysis of the market regarding a new industrial object

If the dynamics ΔES_t has a downward trend, then this indicates that the segment of the market is on the rise. If its rising – then the segment is at a stage of decline, and if the dynamics is constant conditionally (the deviation is not significant), then the segment is at the stage of maturity.

To perform the analysis in this way, we should take into consideration an impact of seasonality on a magnitude of sales of certain types of products, as well as an average life cycle of products. They determine a choice of a correct time period for analysis of a life cycle of a market segment.

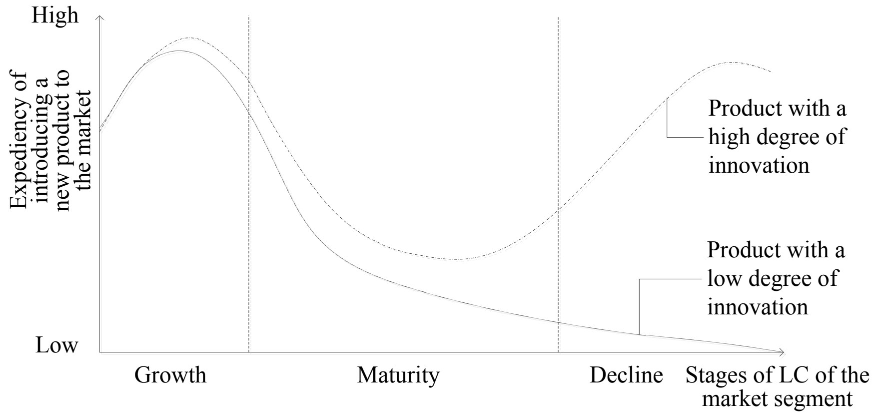

Fig. 3. Expediency of introducing a new product to the market

The capacity of the market segment is an absolute indicator, and it can have different sensory load for various industrial objects. This indicator is complex in terms of its interpretation, and as a consequence, application. Therefore, it makes sense to use a relative indicator, which shows the ability of a new industrial object to provide a free market segment and a segment planned to capture from competitors with innovative products in the analysis of the capacity of a market segment. We denote this indicator as F, then the formula for its calculation will take the form (9):

$$F=E-K+(K^*m), \qquad (9)$$

where E is the capacity of a market segment, ths. prod. units, K is the capacity of a market segment, which belongs to competitors, ths. prod. units., m is the percentage of a market segment of competitors planned to capture, shares of a unit.

We determine the magnitude of production of an innovation product by a new industrial object as f, then the condition $f \geq F$ is obligatory for the full coverage of a potential market segment. Moreover, the minimum f value, at which production of an innovation product is possible, is equal to a volume of production at the break-even point, that is, fbp, ths. prod. units. We calculate it from formula (10):

$$fbp=fc/(c-ac), \qquad (10)$$

where fc are the fixed costs, a.u., c is the price per unit of a product, a.u., ac are the average variable expenditures per unit of product, a.u.

Consequently, the conditions $fbp \leq f$ and $f \geq F$ are obligatory to meet needs of consumers in the potential market segment.

The next indicator is the analysis of competitors in the industry. We can use an indicator of coverage of a market segment for analysis. Thus, if a share of coverage is more than fifty percent, then this company is a leader in the industry. High investment volumes are necessary for the competitive struggle with it in the early stages of operation of a new industrial object. If there are many small and large competitors in the market segment, the process of bringing a new product to the market requires lower investment costs. Popularity of a competitor brand is also important, because the more popular a brand is, the more money you need to spend on the strategy of bringing of a new product to the market. It is advisable to analyze probability of entering of newcomers to the market and to formulate mechanisms for responding to them with the establishment of a reserve fund in advance. The indicator of diversity of a products range is of great importance in this segment of the market, since the larger a product range is, the more difficult and more expensive is to bring an innovative product to the market.

In addition, it is necessary to analyze existing sales channels during the analysis of the market for implementation of a new product of an industrial object. In particular, it is necessary to consider a degree of their monopolization. Thus, the introduction of a new product of an industrial object into the market in the presence of monopolized channels of product sales is complicated because of a need to conclude contracts with existing sales channels.

Thus, at this step, it is necessary not only to conduct a detailed analysis of competitors, but also to determine a strategy of interaction with them. After determination of a strategy, it is necessary to determine its value and to calculate a rate of return of a new industrial facility during and/or after implementation of the strategy, i. e. to calculate p_s. We should take into consideration the fulfillment of the condition $p_s \geq p_{opt}$ at consideration of the decision on feasibility of implementation of a project for construction of a new industrial object. We propose to refuse the realization of a project if there is no fulfillment of the condition, or to determine how much lower is the calculated rate of return value than the acceptable norm for a company and how it changes over time, and then to draw conclusions on feasibility of a project.

The next step is to analyze technological capabilities of a new industrial object, in particular: a level of production manufacturability (i_t), speed of innovation introduction (i_v) and resource availability of production (i_r). These indicators are subjective, because they depend largely on expert judgment or a decision maker. Therefore, it is expedient to bring their linguistic characteristics to score points for adequate application in conduction of market analysis, and to draw a conclusion on the feasibility of a project based on the amount of points. Table 2 presents the scale of linguistic characteristics of the indicators with corresponding score points.

After determination of a score of each indicator, we determine the total indicator of manufacturability of new production T by the formula (11):

$$T=i_t+i_v+i_r, \qquad (11)$$

where T is the total indicator of manufacturability of new production, point, i_t is the score assessment of a level of manufacturability of PCIO production, point, i_v is the score assessment of a speed of innovations introduction in new production, point, i_r is the score assessment of resource availability of new production, point.

If the total index is $T \in [8; 9]$, it is advisable to decide on the implementation of PCIO, since such high values of the indicator prove a high level of manufacturability of new production, which is a potential competitive advantage, as well as a barrier for an output of other enterprises with similar products to the market.

Table 2

Scale of linguistic characteristics with corresponding score points

Indicator	Linguistic characteristic	Score
Level of manufacturability of production (i_t)	Low level	1
	Medium level	2
	High level	3
Speed of innovations introduction (i_v)	Low speed	1
	Medium speed	2
	High speed	3
Resources availability of production (i_r)	Resources are specific and inaccessible	1
	Resources are available	2
	Resources are unified and distributed	3

If T∊[5; 7] it is expedient to carry out an additional analysis.

The purpose of it will be identification of opportunities to improve a level of manufacturability of new production. If there are such opportunities, it is necessary to carry out an assessment of the cost of implementation of innovations, and an analysis of how innovation will affect the rate of return on a new industrial object. If the calculated rate is significantly lower than p_{opt}, then it is necessary to refuse from a project, if the indicator has a minor deviation, then we should accept a project for implementation.

If T∊[3; 4] it is better to refuse from implementation of PCIO, since this production will have a low level of innovation, and as a consequence, a significant number of competitors.

We propose to assess preferences of consumers of products of a new industrial object at the next step of the market analysis. The base indicators for the analysis are: a frequency of use of a product of a new industrial object (u_f), consistency of a demand for a new product (u_c), a hidden demand for a new product (u_h) and a level of loyalty to existing products in the market (u_l).

Calculation of mentioned indicators in absolute terms is expensive and long-term process. Calculated data may have a large error if a level of innovation of a new product is high. This may lead to over-expenditure on implementation of PCIO. Thus, it is necessary to conduct an analysis of consumers' preferences to conclude on feasibility of a project at the stage of its initiation. We propose to do this in scores. Table 3 presents the scale of linguistic characteristics of the indicators in score points.

After determination of a score estimate of each indicator, we can calculate the total indicator of preferences of consumers of new production U according to formula (12):

$$U=u_f+u_c+u_h+u_l, \quad (12)$$

where u_f is the frequency of use of a product of a new industrial object, point, u_c is the consistency of demand for a new product, point, u_h is the presence of a hidden demand for a new product, point, u_l is the level of loyalty to existing products on the market, point.

If U∊[10; 12], then it is advisable to implement a project, because high scores indicate that consumers are interested in a new product.

If U∊[7; 9], then an additional analysis of a structure of the indicator is necessary, that is, it is necessary to determine which components are low and how to improve characteristics of a new product in order to increase U. It is also necessary to determine a cost of such improvement of a product and to determine how this will affect the rate of return for an enterprise. If the calculated norm has an insignificant deviation, then it is advisable to accept a project for implementation, and if it is significantly lower than p_{opt}, then it is necessary to refuse from a project.

If U∊[4; 6], implementation of a project is not appropriate.

Table 3

Scale of linguistic characteristics of indicators with corresponding scores

Indicator	Linguistic characteristics	Score
Frequency of a use of a product of a new industrial object (u_f)	Seldom or never	1
	Sometimes, from time to time	2
	Often	3
Consistency of demand for a new product (u_c)	Alternating demand	1
	Conditionally steady demand	2
	Steady demand	3
Presence of hidden demand for a new product (u_h)	Hidden demand is absent, or it has no significant value	1
	Hidden demand is present, but its value is not critical	2
	Hidden demand is present, and has a significant value	3
Level of loyalty to existing products in the market (u_l).	High loyalty level	1
	Medium loyalty level	2
	Low loyalty level	3

The next step is the LONGPEST analysis. This is a variation of the traditional PEST analysis, which makes possible to determine environmental conditions favorable for project implementation. LONGPEST analysis includes evaluation of all factors at the local, national and global levels. These estimates make possible to get an idea of a state of the external environment at a particular time, and to predict likelihood of changes in subsequent periods. If results of LONGPEST analysis on environment are favorable, then we should implement a project. If not, we should discard a project, because it is almost impossible to reduce an impact of the external environment on a project, and it is not feasible economically to operate under adverse conditions.

Thus, the proposed scheme for assessment of the market for implementation of a new industrial product gives possibility to reduce time and resource costs for analysis and not to lose a significant value of evaluation accuracy, which is of high importance at the initial stage of PCIO. We chose the rate of return of a new industrial object as the resultant indicator. And we should make the decision on implementation of certain PCIO works based on a deviation from its planned value.

4. 3. Improving the method for analysis of competitive advantages of a product of an industrial object

There are two groups of parameters of competitiveness of goods in the classical theory of marketing (Fig. 4).

Companies need to find new properties of already known products to gain sustainable competitive advantages, especially at the stage of creation of a new enterprise, or to enter the market with a non-taxable product. That is, one of the important factors that can affect competitiveness of both individual goods and business in general, is application of various types of innovations in production. It improves production and financial activities in a new and existing institutional environment significantly. That is why we propose to base the methodology for assessment of competitive advantages of a product of an industrial object on indicators of its innovative potential.

The basis of the methodology is the mathematical model of product competitiveness based on the following:

– selection of competitor products must consist of not less than three units;

– provision of standards for possibility of comparison of characteristics of goods that have different dimensions;

– it is necessary to rank goods according to a degree of priority according to expert assessments or assessment of a decision maker (DM) taking into consideration that characteristics of goods have different degrees of importance for a consumer;

– it is necessary to take into consideration that the most successful value of a particular criterion can be as maximum (for example, profit per unit of product) as minimal (for example, cost of goods) in assessment of criteria of an innovative product, which compares alternatives;

– since not all criteria have numerical parameters (for example, a color of a product), it is expedient to assign a numeric (score) value to each value and to determine the highest priority value (minimum or maximum).

Experts or DM determine the priority of product parameters (importance) by points in the range from 1 to 10, then we can determine the sum of priorities for a whole set of characteristics. We can determine the individual relative priority for any parameter by a ratio of its own numerical priority of a parameter to the sum of all priorities by formula (13).

$$a_i = \frac{r_{pri}}{\sum_{i=1}^{n} r_{pri}}, \qquad (13)$$

where a_i is the relative priority of any i-th parameter; r_{pri} is the numerical priority of any i-th parameter; n is the number of parameters, which we need to compare.

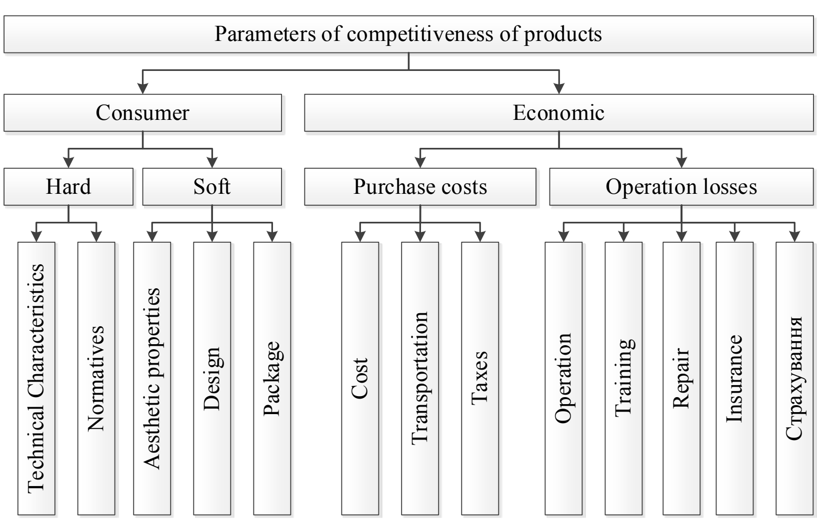

Fig. 4. Traditional system of indicators, which characterize competitiveness of goods

The sum of all relative priorities is equal to unity.

We denote a standardized value of the same parameters relatively to the best parameter of any of the compared variants as μ_i.

We carry out standardization of product parameters by the ratio of single-type numerical characteristics of parameters of all competing goods to numerical characteristics of a parameter-leader, which we take as a unit. Parameters of other competing goods will be a fraction of a unit. That is, if a parameter, under which the comparison goes, maximizes, then we choose the largest numerical value of this parameter among alternatives presented, and we take this value as the reference one, that is, $\mu_i=1$. We obtain the remaining μ_i values by dividing the numerical characteristic of the compared indicator into a reference value.

If the parameter, under which the comparison goes, minimizes, then we choose the least value of this parameter among the alternatives presented, and we also take this value as the reference, that is, $\mu_i=1$. But we obtain the calculation of other μ_i values by dividing the reference value into the numerical characteristic of the compared indicator.

The basis for evaluation of competitiveness of each option is the calculation of the indicator of innovative potential M_j (14) by calculation of the maximum of the weighted sum. The leader will be a product that receives the highest value of the sum of products of the priority coefficient a_i on the standardized value of μ_i characteristic.

$$M_j = \sum_{i=1}^{n} \mu_{ij} a_i \Rightarrow \max, \qquad (14)$$

where μ_{ij} is the normalized value of i parameter and j alternative.

To calculate a coefficient of fluctuation of the standardized characteristics relative to the innovation potential, it is necessary to determine a mean square deviation according to the formula (15).

$$\sigma_j = \sqrt{\sum_{i=1}^{n} (\mu_{ij} M_j)^2 a_i}, \qquad (15)$$

where σ_j is the root mean square deviation from the innovation potential.

We can carry out the calculation of the coefficient of fluctuation of standardized characteristics relatively to the innovation potential by formula (16).

$$\gamma_j = \frac{\sigma_j}{M_j}. \qquad (16)$$

The smaller is the value of the coefficient of fluctuation of standardized characteristics relatively to the innovation potential, the better, since it indicates that alternatives with the highest priority have the largest values.

Let us take such a product with all normalized characteristics equal to one as an ideal product, then the innovative potential for M_{per} is also equal to one. We determine a level of deviation of characteristics of an innovative product from the ideal by formula (17).

$$\Delta M_{jper}=1-M_j, \tag{17}$$

where ΔM_{jper} is the deviation of innovative potential of an alternative from the ideal value. This indicator should tend to a minimum, since the most attractive is the alternative, which is closest to the ideal.

For further analysis, we compare innovative products in pairs. We form pairs from the nearest competitors and take the indicator with the maximum value of the innovative potential. That is, we calculate a private index and a general index of advantages of an innovative product over its closest competitor according to the formulas (18) to (21).

We calculate the private index of an advantage of an innovative product over the nearest competitor by mathematical expectation (innovative potential) as follows:

$$J_{M_j}=\frac{M_{jp}-M_{jcom}}{M_{jp}}, \tag{18}$$

where M_{jp} is the value of the innovation potential of an innovative product; M_{jcom} is the value of the innovation potential of a competitor's product.

This indicator shows how an innovative product exceeds the competitor's product by the indicator of the innovation potential.

Similarly, we calculate the index of deviations from the ideal value (19).

$$J_{\Delta M_{jper}}=\frac{M_{jbestcom}-\Delta M_{jbestp}}{M_{jbestcom}}, \tag{19}$$

where ΔM_{jbestp} is the value of a deviation of the innovation potential from the ideal value of an innovation product; $M_{jbestcom}$ is the value of a deviation of the innovative potential from the ideal value of a product-competitor.

This index shows how much the innovative product exceeds the competitor's product by the rate of deviation of the innovative potential from the ideal value.

We calculate the index of fluctuations of standardized characteristics relative to the innovation potential by formula (20).

$$J_{\gamma j}=\frac{\gamma_{jcom}-\gamma_{jp}}{\gamma_{jcom}}, \tag{20}$$

where γ_{jcom} is the value of fluctuation of standardized characteristics relative to the innovation potential of a competitor product; γ_{jp} is the value of fluctuation of standardized characteristics relative to the innovation potential of an innovation product.

We calculate the general index of an advantage as the sum of private indices. It shows the total amount for which an innovative product exceeds a nearest competitor product (21).

$$J_{com}=J_{Mj}+J_{\Delta Mjper}+J_{\gamma j}. \tag{21}$$

4. 4. Improving the model for choosing a supplier of specific equipment for an industrial object

There are different methods to solve the problems of selection of effective technological solutions from a certain set of options. A focus of most of them is a use of cardinal (numeric) information. Such methods include a method of prioritizing, a score rating estimation, a method of acceptability categories, a method of costs estimation, a method of dominant characteristics, etc. However, there are tasks that require information of an ordinal (serial) nature or information of both natures at the same time in the practice of decision-making on initiation of PCIO. That is, in presence or absence of information about importance of performance indicators, because of the need to take into consideration many factors of economic, technical and productive nature.

Making an economically sound and well-grounded management decision to purchase specific equipment gives possibility to minimize investment costs of PCIO, and, in the future, operation costs of an enterprise.

Selection of a supplier of specific equipment for an industrial object is complex due to presence of a number of powerful manufacturers of the same equipment on the market or to the complete lack of proposals that can provide the innovative potential of a finished product. In the first case, it complicates definition of the optimal option, as aggravation of competition forces to improve constantly terms of sale, service, quality and prices. And in the second case, it is related to lack of equipment required characteristics. Therefore, there is a need to create an objective assessment tool that gives possibility to find reasonable solution, which meets objectives of PCIO.

It is expedient to use the vendor choice model based on a fuzzy logical method, which uses compositional aggregation rules for description of alternatives with information on advantages for a decision maker. The model will give possibility to assess expediency of a work with the selected supplier in the presence of all necessary information that can be processed by a relevant information system. According to the proposed model, a decision-making process consists of the following steps:

Step 1. Determination of supplier evaluation criteria.

A set of criteria provides the expediency of selection of a supplier from several possible ones. Experts determine a weight of some suppliers, analytical calculations – of other suppliers. We base the proposed model of supplier comparison on the following criteria:

Cost of equipment. Typically, this criterion is critical. In this model, a cost of equipment is a complex indicator that takes into consideration a cost of specific equipment, a cost of supply (including transport, customs, etc.), installation works;

Due date of an order. Includes duration of production of equipment, delivery time and installation;

Terms of payment. Based on availability and volume of subscription;

Reliability of a supplier. Reliability refers to ability of a supplier to provide installed quality equipment in accordance with a level of competitiveness and technical parameters at a specified price within certain time limits.

Stability. Characterizes continuity of contract terms.

Quality of equipment. This indicator takes into consideration not only qualitative technological parameters of equipment and its reliability directly, but also a quality of technical support of a manufacturer (training, availability of technical documentation, certificates and other permits, availability of service, supply of spare parts, etc.);

Competitiveness. A characteristic that reflects a difference from equipment of a competitor, that is, ability to provide an indicator of an overall index of advantages of an innovation product (21);

Environmentally favorable equipment. An environmental coefficient (k_e) characterizes efficiency of any production.

We can define it as a difference between a cost of raw materials taken per unit and a cost of generated waste (w).

$$k_e=(1-w), \quad (22)$$

where w is the cost of waste production reflected in a percentage of a cost of raw materials, a share of unit.

Fluctuations of k_e value in the range from 0.9 to 1 indicates high ecological efficiency of production and a low level of environmental pollution.

Step 2. Installation of a supplier parameters package.

Taking into consideration characteristics of the above criteria of assessment, we establish parameters for the supplier's choice: x_1 is the cost of equipment; x_2 is the due date of an order; x_3 are the terms of payment; x_4 is the supplier reliability; x_5 is stability; x_6 is the quality of equipment; x_7 is competitiveness; x_7 is the environmentally friendly equipment.

The task is as follows: we need to choose one supplier from N set of potential suppliers that produce similar equipment. The supplier should meet the requirements specified above. In accordance with the method of multicriteria selection of alternatives based on the rules of fuzzy derivation [12], N is the set of suppliers, A is its fuzzy subset, a degree of membership of elements to it is a number from the single interval [0; 1]. The subsets A_j are values of X linguistic variable. We assume that the set of criteria $x_1, x_2, ..., x_p$, that is, the linguistic variables given on the basic sets $n_1, n_2, ..., n_p$ respectively, characterizes the set of solutions. A set of several criteria with corresponding values characterizes a perception of a decision maker on satisfaction with an alternative, which is denoted by β variable and it is also linguistic. Bearing in mind the meaningful characteristics of the supplier's evaluation criteria, we form an expression that describes the satisfaction of the alternative. In general, m expression takes the form (23).

m: If
$x_1=A_{1i}$, and $x_2=A_{2i}$, and ... $x_p=A_{pi}$, then $\beta=B_i$. (23)

Taking into consideration the introduced x symbols, m expression can take the form:

m_1 – "If a supplier offers equipment at a low price, time of execution of an order is minimal, equipment is of the required quality (high), then a purchase option (supplier) satisfies";

m_2 – "If a supplier offers equipment at a low price, time of execution of an order is minimal, equipment is of the required quality (high) and a company of a supplier proved its reliability, then a purchase option (supplier) more than satisfies";

m_3 – "If a supplier offers equipment at a low price, equipment is of the required quality (high), the environmental factor is in the range from 0.9 to 1, a deadline for an order is minimal, a customer offers convenient forms of payment, a high level of stability, then a purchase option (supplier) is optimal to a high degree";

m_4 – "If a supplier offers equipment at a low price, equipment is of the required quality (high), time of execution of an order is minimal (high speed delivery), a customer offers convenient forms of payment, a high level of stability, the coefficient of environment is in the range from 0.9 to 1, a supplier proved to be reliable, then a purchase option (supplier) is very satisfying ";

m_5 – "If a supplier offers equipment of the required quality (high), delivers in minimal terms (high speed of delivery), a customer offers convenient forms of payment, a high level of stability, the environmental factor is in the range from 0.9 to 1, a supplier proved his reliability and can provide innovative potential, then a purchase option (supplier) more than satisfies ";

m_6 – "If a supplier offers equipment at a very high price, products are of inadequate quality (low, medium), long delivery times, then a purchase option (supplier) is unsatisfactory".

For formulation of the rules, we give the following possible values of linguistic X_i and Y variables, which serve to evaluate suppliers:

m_1: If X_1=*low*, X_2=*minimal*, X_6=*high* =>Y=*satisfies*; (24)

m_2: If X_1=*not high*, X_2=*minimal*, X_6=*high*,
X_4=*reliable*=>Y=*satisfies*; (25)

m_3: If X_1=*not high*, X_6=*high*, X_8=*satisfying*, X_2=*minimal*,
X_3=*convenient*, X_5=*high*=>Y=*satisfies*; (26)

X_1=*not high*, X_6=*high*,

m_4: If X_2=*minimal (high speed delivery)*;
X_3=*convenient*, X_5= *high*, X_8=*satisfying*,
X_4=*reliable* =>Y=*satisfies*; (27)

X_6= *high*, X_2=*minimal (high speed delivery)*,
m_5: If X_3=*convenient*, X_5=*high*, X_8=*satisfying*;
X_4=*reliable*, X_7=*provided*=>Y=*satisfies*; (28)

m_6: If X_1=*high*, X_2=*long term*,
X_6=*low/medium* =>Y=*is unsatisfactory*. (29)

Table 4 presents the values of Y variable given with a use of membership functions.

Table 4

The value of Y variable

Content value of Y	Definition
β= satisfies	$\mu_\beta(X)=X, x \in J$
M β=more than satisfies	$\mu_{M\beta}(X)=\sqrt{x}, x \in J$
Bes t=ideal	$\mu_B(X)=\begin{cases}1, & \text{if } x=1,\\ 0, & \text{if } x<1,\end{cases} \quad x \in J$
Sβ= very satisfying	$\mu_{S\beta}(X)=x^2, x \in J$
Neg β= not satisfying	$\mu_{Neg\beta}(X)=1-x, x \in J$

We choose from N set of alternatives $=\{n_1, n_2,..., n_k\}$. In the task of the choice of a supplier, the following fuzzy sets express a level of assessment:

– low cost

$$A=\{a/n_1, a/n_2, ..., a/n_k\}, \quad a \in [0;1];$$

– short time of order fulfillment

$$B=\{b/n_1, b/n_2, ..., b/n_k\}, \quad b \in [0;1];$$

– convenient terms of payment

$$C=\{c/n_1, c/n_2, ..., c/n_k\}, \quad c \in [0;1];$$

– sufficient reliability

$$D=\{d/n_1, d/n_2, ..., d/n_k\}, \quad d \in [0;1];$$

– stability

$$E=\{e/n_1,e/n_2,...,e/n_k\},\quad e\in[0;1];$$

– high quality

$$F=\{f/n_1,f/n_2,...,f/n_k\},\quad f\in[0;1];$$

– provides competitiveness

$$G=\{g/n_1,g/n_2,...,g/n_k\},\quad g\in[0;1];$$

– satisfies environmental characteristics

$$H=\{h/n_1,h/n_2,...,h/n_k\},\quad h\in[0;1].$$

Taking into consideration the introduced symbols, m_1–m_6 take the form:

$$m_1\text{: If } A\text{and}B,\text{and}F\Rightarrow\beta; \qquad (30)$$

$$m_2\text{: If } A\text{and}B,\text{and}F,\text{and}D\Rightarrow M\beta; \qquad (31)$$

$$m_3\text{: If } A\text{and}G,\text{and}H,\text{and}B,\text{and}C,\text{and}E\Rightarrow Best; \qquad (32)$$

$$m_4\text{: If } A\text{and}F,\text{and}B,\text{and}C,\text{and}E,\text{and}H,\text{and}D\Rightarrow S\beta; \qquad (33)$$

$$m_5\text{: If } F\text{and}B,\text{and}C,\text{and}E,\text{and}H,\text{and}D,\text{and}G\Rightarrow M\beta; \qquad (34)$$

$$m_6\text{: If } \text{noA},\text{noB},\text{noF}\Rightarrow Neg\beta. \qquad (35)$$

Step 3. Identification of the most promising alternative.

We describe satisfaction of the alternative by fuzzy *A* subset with *N*. We can determine it based on the compositional rule of conclusion:

$$B=A^{\circ}D, \qquad (36)$$

where *B* is the fuzzy subset of *I* interval.

Comparison of alternatives goes based on point estimates. We define α-level set $(\alpha\in[0;1])$ for $C\subset I$ fuzzy set:

$$C_\alpha=\{i|\mu_C(i)\geq\alpha\in I\}. \qquad (37)$$

For each C_α, we calculate an average number of elements – $M(C_\alpha)$ for a set of *n* elements. We determine a point value for *C* set by formula (38).

$$F(C)=\frac{1}{\alpha_{\max}}\int_0^{\alpha_{\max}}M(C_\alpha)\mathrm{d}x, \qquad (38)$$

where $\alpha_{\max}$ is the maximum value in *C* set.

We find satisfaction for each alternative at selection of alternatives and calculate a corresponding point score. The best one is the alternative with the highest value of point estimate.

5. A test case for implementation of the integration-analytical method for initiation of construction projects of industrial objects

We considered six enterprises, which operate in the industry at the first stage of realization of the integration-analytical method of initiation of industrial construction projects according to the scheme of express assessment of investment attractiveness of the industry. We made the choice of the industrial branch based on the wishes of initiators of PCIO.

We calculated *EV/EBITDA* ranges by a multiplier in 2017, *EBITDA* growth for 2017 and *EBITDA* growth forecast for 2018 based on the performance indicators of the selected enterprises. We determined average industry values. We performed all calculations in US dollars. Table 5 presents the values obtained.

Table 5

Indicators of sample enterprises

Company	*EV/EBITDA* range by a multiplier in 2017, %	Revenue (*S*) in 2017, ths. a.u.	*EBITDA* growth in 2017, %	*EBITDA* growth forecast for 2018, %
1	215.46	266.78	8.50	8.61
2	136.53	134.62	11.23	12.70
3	253.12	159.58	17.18	19.03
4	128.1	96.50	22.47	25.47
5	105.53	146.85	17.92	20.23
6	220.39	201.05	31.93	34.31
Average per industry	176.52	167.56	18.21	20.06

We found that all the companies under investigation have positive *EBITDA* dynamics based on the data obtained. The companies are profitable. Three companies have the result higher than the average one in the industry, which indicates prospects of the industry for implementation of PCIO. Based on received information, we also revealed that an industrial object should plan result indicators of activity not lower than the average one in the industry to conduct an effective economic activity.

We should take the average value of the revenue in the industry as the starting point in analysis of the market for a sale of a product of a new industrial object. We can calculate the desired rate of return of a new industrial object on its basis, and to form P_{opt} – a value of the ratio of the planned market price of a product to its cost, which fulfills the condition for profitability of a new industrial object.

Let us demonstrate realization of this step of the integration-analytical method of PCIO initiation. We assume that P_{opt} should be equal to 2.3 to ensure the annual level of profitability of a new industrial object in the amount of USD 310,000 at the unit cost price of USD 138.1. Then, under these conditions, we consider the level of market profitability. To do this, we determine maximum and minimum prices for this type of a product. Let the highest price be USD 335.8, and the lowest one is USD 298.5. Then $P_{\max}$= =335.8/138.1=2.4, respectively, $P_{\min}$=298.5/138.1=2.16. Since P_{opt} is between the maximum and minimum values and it is greater than 1, then we consider that this market segment is profitable under given conditions. Thus, we analyze the stage of the life cycle of the market segment. A base of this analysis of the market segment is estimation of dynamics of a difference between capacity of the market segment and a volume of offers of competitors for a certain period. Let us assume that the analysis of dynamics of a difference for a year showed that a deviation is insignificant, that is, that the segment of the market is in the stage of maturity. This indicates a need for additional consideration of a new product in terms of its innovation. Because the innovation of a product makes possible to increase its competitiveness significantly.

For the example, which is under consideration, we know that a new product will have an innovative component. That is, it is possible to carry out further evaluation of the segment of the market of new products.

The next step is to analyze ability of a new product to meet a need for a market segment in a new product. In order to implement this step of the analysis, first of all, it is necessary to determine a volume of production of a new product at the break-even point, that is, to calculate f_{bp}. We assume that for new production f_{bp}=4,000 prod. units. Second, we determine F value as a difference between the existing market capacity and the capacity of a competitor's market, taking into consideration a size of the market that is planned to by captured from competitors. We assume, for example, the total capacity of the market is 10,000 prod. units. A value that competitors have is 7,000 prod. units. The percentage of the competitive market segment that is planned to capture is 30 %, then F=10,000–7,000+(7,000·0.3)=5,100 (prod. units).

For the further analysis, we determine the maximum F value, for which is the calculated production capacity of a new industrial object calculated. For our example, f==8,500 prod. unit. Thus, the condition $f \geq F$ is satisfied, that is, the production capacity of a new industrial object is capable to ensure the full market demand of a given segment of the market. And there is the condition $f_{bp} \leq f$, satisfied, which indicates that the provision of new market segments will not lead to losses for a new industrial object.

The next step is to analyze competitors in the industry and to develop a strategy for interaction with them. In the future it is necessary to calculate a cost of implementation of this strategy taking into consideration a time factor, and to investigate how its implementation will affect a level of profitability of a new industrial object. That is, to analyze meeting the $f_{bp} \leq f$ condition. In the case of not meeting the condition, it is expedient to make a decision to refuse from the implementation of PCIO.

It is necessary to determine a level of technological capability of a new industrial object based of experts' assessments, or a person making a decision and initiating PCIO. Since the estimation of the given indicator is sufficient at the stage of initiation of PCIO, then we can use a linguistic assessment with a score scale presented in Table 2. Let us assume that T=8 for estimated new industrial object, that is, the implementation of the project is feasible in terms of technological capabilities of PCIO. Similarly, we estimate preferences of consumers of a product of a new industrial object. Table 3 presents the scale for their evaluation. Let us assume that U=11 for the estimated new industrial object, that is the implementation of the project is appropriate in terms of preferences of consumers.

The next step is to perform a traditional LONGPEST analysis of the construction environment of a new industrial object. It makes possible to determine a level of environmental friendliness for implementation of PCIO. We accept the results of the LONGPEST analysis for PCIO, which we consider as an example, as favorable. That is, we consider the project recommended for implementation.

The third step in the assessment of PCIO at the stage of its initiation is a detailed assessment of competitiveness of a new industrial object. We propose to use the improved method of assessment of competitive advantages of a product of an industrial object based on indicators of its innovative potential for this assessment in the study. We select two products (A and B) that have approximately similar characteristics for the comparative evaluation, since innovative products do not have similar competitors' products generally. We denote the innovative product, with which the comparison will be made, as C.

We compare goods according to four most widespread criteria, namely: a unit product price, a.u.; a unit weight, g; availability of additional characteristics, yes/no; material used for manufacturing, points. To select the best product option, we need to determine score assessments for qualitative parameters of products. We denote the presence of additional characteristics as 1 point, and their absence as 0 points. The materials of which the products are made are: wood – 7 points, plastic – 3 points, and glass – 1 point. We define those parameters, the best values of which are minimized, and those values, which are minimized. For our example, a criterion "weight" is minimized, and all others are maximized.

By means of the expert estimation method, we determine the priority of each criterion on a 10-point scale, that is, we determine importance of each criterion. We calculate the individual relative priority for each criterion according to the formula (13). Let us summarize the obtained data into Table 6.

Table 6

Product parameters

Criterion \ Product	A	B	C	Priority of a product criterion	Individual relative priority of each product criterion
Price, a.u.	100.75	55.97	85.82	10	0.37
Weight, g	500	700	200	3	0.15
Existence of additional characteristics, point	1	0	1	5	0.19
Material for production, point	3	1	7	8	0.29
Total				26	1

Let us calculate the normalized values of all product parameters. We denote the best option as 1. We define the innovation potential, the mean square deviation and the coefficient of fluctuation by formulas (14) to (16). Let us summarize the obtained data in Table 7.

Table 7

Calculated parameters

Criterion \ Product	A	B	C
Price	1.000	0.556	0.852
Weight	0.400	0.286	1.000
Presence of additional characteristics	1.000	0.000	1.000
Material for production	0.429	0.143	1.000
M_j	0.742	0.290	0.945
σ_j	0.288	0.048	0.05
γ_j	0.388	0.166	0.053

From the results obtained, it follows that C product has the smallest spread of characteristics, that is, that the basis of the competitiveness of a product is the indicator with the highest priority, that is, the price.

We calculate the level of deviation of characteristics of the innovative product from the ideal one by formula (17)

$\Delta M_{jper\,A}$=1–0.742=0.258;

$\Delta M_{jper\,B}$=1–0.290=0.71;

$\Delta M_{jper\,C}$=1–0.945=0.055.

We determine from the calculations that we can consider C innovative product as the best one. Therefore, we calculate the private indices of advantages of C innovation product over the nearest A competitor and another B competitor.

$J_{Mj}A$=(0.945–0.742)/0.945=0.16;

$J_{Mj}B$=(0.945–0.290)/0.945=0.69.

We calculate the index by deviation from the ideal value from formula (19).

$J_{\Delta Mjper}A$=(0.258–0.055)/0.258=0.78;

$J_{\Delta Mjper}B$=(0.71–0.055)/0.71=0.92.

We calculate the fluctuation index of the normalized characteristics relatively to the innovation potential from formula (20)

$J_{yj}\,A$=(0.388–0.053)/0.388=0.86;

$J_{yj}\,B$=(0.166–0.053)/0.166=0.68.

We calculate the general index of advantages from formula (21).

$J_{com}A$=0.16+0.78+0.86=1.8;

$J_{com}B$=0.69+0.92+0.68=2.29.

As a conclusion, we can state that product C is 1.8 times better than product A, and is 2.29 better than product B based on the general index of advantages. That is, a new innovative product is competitive.

The last step is to evaluate and select a supplier by using the rule of fuzzy logical conclusion. We identified eight criteria for comparison of suppliers of specific equipment for PCIO in the study. But there are five packages of supplier parameters that are capable to meet needs of PCIO. We consider the resulted calculation as an example of implementation of a supplier's assessment with a use of the rule of fuzzy logical derivation.

As an example, let us consider a sample of five suppliers N={n_1, n_2, n_3, n_4, n_5} with the following criteria estimates:

– low cost A={0.7/n_1; 0.5/n_2; 0.4/n_3; 1/n_4; 0.9/n_5};

– short time of delivery of an order B={0.6/n_1; 0.3/n_2; 0.7/n_3; 0.8/n_4; 0.4/n_5};

– convenient conditions of payment ={0.5/n_1; 0.2/n_2; 0.8/n_3; 0.3/n_4; 0.9/n_5};

– sufficient reliability D={0.2/n_1; 0.4/n_2; 1/n_3; 0.4/n_4; 0.7/n_5};

– stability E={0.5/n_1; 0.9/n_2; 0.7/n_3; 0.6/n_4; 0.4/n_5};

– high quality F={0.7/n_1; 0.4/n_2; 0.7/n_3; 0.5/n_4; 0.3/n_5};

– provides competitiveness G={0.5/n_1; 0.3/n_2; 0.1/n_3; 0.6/n_4; 0.4/n_5};

– satisfies environmental characteristics H={0.2/n_1; 1/n_2; 0.4/n_3; 0.8/n_4; 0.4/n_5}.

After application of selection rules (30) to (35) we have the following expressions:

M_1={0.6/n_1; 0.3/n_2; 0.4/n_3; 0.5/n_4; 0.3/n_5};

M_2={0.2/n_1; 0.3/n_2; 0.4/n_3; 0.4/n_4; 0.3/n_5};

M_3={0.5/n_1; 0.2/n_2; 0.1/n_3; 0.6/n_4; 0.4/n_5};

M_4={0.2/n_1; 0.2/n_2; 0.4/n_3; 0.3/n_4; 0.3/n_5};

M_5={0.2/n_1; 0.2/n_2; 0.3/n_3; 0.3/n_4; 0.3/n_5};

M_6={0.4/n_1; 0.8/n_2; 0.6/n_3; 0.5/n_4; 0.7/n_5}.

We obtain $D_{1\text{-}6}$ fuzzy sets formed based on the data acquired using the rule for the transformation of an implication

$$D_1 = \begin{matrix} n_1 \\ n_2 \\ n_3 \\ n_4 \\ n_5 \end{matrix} \left\| \begin{matrix} 0,6 & 0,7 & 0,8 & 0,9 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0,3 & 0,4 & 0,5 & 0,6 & 0,7 & 0,8 & 0,9 & 1 & 1 & 1 \\ 0,4 & 0,5 & 0,6 & 0,7 & 0,8 & 0,9 & 1 & 1 & 1 & 1 \\ 0,5 & 0,6 & 0,7 & 0,8 & 0,9 & 1 & 1 & 1 & 1 & 1 \\ 0,3 & 0,4 & 0,5 & 0,6 & 0,7 & 0,8 & 0,9 & 1 & 1 & 1 \end{matrix} \right\| .$$

Formula (38) calculates point estimates for each alternative. For our example, the point alternatives are: n_1 – 0.428; n_2 – 0.432; n_3 – 0.365; n_4 – 0.327; n_5 – 0.523.

Since the alternative with the highest point value is the best, then n_5 supplier has the greatest advantage.

6. Discussion of the results of development of the integration-analytical method for initiation of projects of construction of industrial objects

The main advantage of development of the integration-analytical method of initiation of PCIO is its relevance for processes of project management in the industrial sector. This sphere is associated with significant investment costs, high innovation, non-typical life cycles of projects, and a determining role of specific resources for PCIO. In addition, the method is less costly in terms of time and resource indicators compared to similar methods, since it includes only compulsory elements for evaluation only, due to its adaptation to the specific nature of PCIO.

The disadvantage of the proposed method is a variety of procedures and mechanisms used in analysis of options for projects of construction of industrial objects at the initiation stage, which requires specialists of high qualifications for analysis.

The practical value of the research results lies in ability of one integrated analytical tool to provide a multicriteria analysis of PCIO at the stage of its initiation. And to make a reliable management decision as to feasibility of implementation of PCIO based on received data. The scope of the method includes industries characterized by a high level of innovation in production and a degree of uncertainty.

The integration-analytical method of initiation of projects of construction of industrial objects presented in the study fully corresponds to the conceptual model of the initiation phase of PCIO [9], which confirms the logical and consistent work of authors on PCIO management problem.

Automation of the proposed procedures and mechanisms of the integration-analytical method for initiation of projects of construction of industrial objects requires subsequent revisions.

7. Conclusions

We developed an integration-analytical method of initiation of projects of construction of industrial objects in the study. Unlike the existing ones, the given method is complex, based on the specific life cycle of PCIO, it takes into consideration the innovative component of projects and availability of specific and unified resources necessary for PCIO implementation. Due to the integration of modern analytical tools into a single method, we achieve elimination of cases of dual analysis of indicators and exclusion of inappropriate criteria, a reduction in resource and time spent on management of PCIO.

1. We formulated a mechanism for formalization of the idea of PCIO as an investment object during the development of the integration-analytical method of initiation of projects of construction of industrial objects. The base of the mechanism is an analysis of investment attractiveness of PCIO implementation with a help of express assessment. The proposed mechanism makes it possible to determine the most attractive industry from the position of investments, as well as to identify potential competitors and to establish a forecast rate of return of an enterprise o f a new industrial object. That is, its focus is improvement of a quality of managerial decisions at the stage of PCIO initiation.

2. We developed a procedure for analysis of the market for implementation of innovative products of PCIO, which is a step-by-step analytical mechanism of seven indicators. Namely: a level of profitability of the market segment, analysis of its life cycle, a level of capacity of an industrial object to meet market needs, an influence of competitors, a level of technological capabilities of an industrial object, consumers' preferences, favorable external factors. A combination of approaches to the analysis of coefficients can reduce time and resource costs for market analysis not losing the accuracy of evaluation, which is of high importance at the initial stage of PCIO.

3. We have improved the method of analysis of competitive advantages of an innovative product of PCIO, which, unlike the existing criteria, uses the best indicator among comparative products and not a theoretical value. In addition, the procedure for this method includes an analysis of product characteristics that do not have clearly defined numerical parameters and makes it possible to take into consideration a rank of each characteristic according to preferences of DM. We achieved the improvement of a quality of management decisions for PCIO through the analysis of all product characteristics, and a decrease in cost characteristics of the method – due to the application of the score scale for linguistic parameters of a product.

4. We improved the model of a choice of a supplier of specific equipment for PCIO implementation. The base of the model is a use of the fuzzy logic conclusion method by development of a set of criteria specific to equipment suppliers for PCIO. A set of criteria includes a cost of equipment, a deadline for completion of an order, terms of payment, reliability of a supplier, stability, quality of equipment, competitiveness and environmental friendliness. Using these evaluation criteria could significantly reduce resource, time and money costs for performing the assessment of suppliers, and, thereby, to enhancing the quality of PCIO management.

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