Algorithm for the development project’s technology portfolio formation

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Abstract. The article presents the results of a study on the portfolio of technologies formation upon implementation commercial real estate projects. The aim of the study was to investigate the strategies and optimization of forming technology portfolio at the pre-investment stage. The relevance of the article the problems that arise in the interaction of the project organization and the developer. The article proposes a methodology for portfolio formation based on the use of multifactorial space. As a key indicator of decision-making, a priority coefficient has been developed. An algorithm for the formation of a technology portfolio during the implementation of a project at a conceptual stage has been developed; testing was carried out on the example of facade system solutions. The proposed algorithm can complement the existing quality control systems for the stages of design, construction and operation of an investment construction project.

1. Introduction
The conceptual stage is considered the beginning of the project life cycle. It can also be called the initial stage or the initiation stage, and includes the pre-investment and pre-project phases [1]. The conceptual phase, as a rule, is characterized by the lack of accurate and complete information about the project. This can be a general idea and concept of a project, estimated terms for its implementation, preliminary generalized project parameters [2]. At the conceptual stage, 4 main areas of research are distinguished: the project concept, project analysis, feasibility study and business project plan [2]. This article discusses the feasibility study, which, in turn, includes the development of design documentation for the main parameters of the construction object: space-planning, structural, technological, operational, economic, social, and environmental.

One of the key problems that arise during the implementation of an investment construction project is the lack of information necessary for the development of design solutions at the design stage or its insufficient accuracy [3]. Later in attracting third-party Design Company because of its ignorance of the future operation facility specifics' not the most optimal design decisions would be made. Practice shows that designers do not seek to simplify design decisions, so often in the construction phase there are situations when the design decisions are unjustified complexity [4]. This leads to the need to amend the design and working documentation and leads to additional financial and time costs [5]. Often during the design, the post-investment phase is not taken into account, for example, the maintainability of the design solution is not evaluated, and the payback period of the solution is not evaluated [6].
It should be noted that in foreign practice [7] companies seek to minimize the involvement of third-party participants in the implementation of the investment and construction project, such as highly specialized consulting organizations, etc. This allows you to reduce risks in management and to simplify the process of participants’ interaction in investment and construction activities. In the Russian Federation [8], they are currently striving to adopt positive foreign experience, so the so-called development organizations are actively in progress in the real estate market, where a developer means a professional market participant who provides for the creation, management and sale of real estate in a given frame time, within budgetary constraints, often using their own funds [9]. Thus, a developer is an entrepreneur who bears full responsibility for the results of investment activities, creates sustainable business ties at both the production and management levels [10]. It is believed that the activities of the developer are dominated by financial and economic aspects, such as choosing the commercial viability of the project, attracting investments, ensuring the financial and economic sustainability of the project, etc., but, in practice, a significant number of related tasks are being solved [11]. Thus, it could become the future owner and user of the project results.

As a rule, in modern conditions, most developers carry out investment projects from the moment the concept appears until the project is implemented on the open market, thereby carrying out a “continuous life cycle” [12]. Also, the development companies are increasingly creating their own management structures designed to operate a finished property, which allows the creation of a Department of methodology, planning and analytics, the task of which is, inter alia, to develop new methods, standards and algorithms for the implementation of investment and construction projects. Figure 1 shows the universal organizational and managerial structure of a leading domestic development company, involved throughout the entire life cycle of the project, for which authoring is proposed. However, major developers are just beginning to implement such structures. The functions of the Department of the methodology, planning and analysis, each company defines itself, there is no clear understanding of the principles and mechanisms for its operation due to limited experience. Therefore, the proposals developed in this paper can be used similar Departments.

Thus, to solve the above-mentioned problems should be considered a large amount of tasks. In particular, at the strategic planning level, there is a need to form the most effective technology portfolio, which implies the choice of process solutions from the set, together will give a synergistic effect. The synergistic effect, in turn, is expressed in strengthening the effect of the interaction of two or more technological solutions, characterized in that the combined effect of these solutions will exceed the simple sum of the effects of each of these solutions [13]. Under current conditions in the preparation of investment projects necessary to analyze multiple external and internal factors that affect the efficiency of capital investments. As mentioned earlier, the primary goal of creating a technology portfolio is to increase the welfare of owners and investors of a development company. As a measure of determining financial well-being, the profitability and cost of the project are used.

The main document regulating investment and construction activities is the Town Planning Code of the Russian Federation [14]. It provides definitions of the main participants in investment and construction activities. The authors' review of the legislative documentation shows that there is no officially established definition of a "technology portfolio" in regulatory documents.

At the same time, GOST R 50995.0.1.-96 “Technological support for creating products” defines the technological support for creating products as “an organizational and technical system established by a set of interrelated state standards that ensures the organizational, informational and technical unity of technological work carried out at the stages of development and production of products, based on the presentation of the design and technology for producing products as a set of unified design and technological solutions” [15]. In addition, according to the Government Decree of February 16, 2008 No. 87 [16], the subsection “Technological solutions” is part of the section “Information on engineering equipment, networks of engineering and technical support, a list of engineering and technical measures, the content of technological solutions”.

Thus, the technology portfolio is a part of the technological support at the strategic planning level as part of the project management. A study of scientific information shows that there is little research on the topic of forming a technology portfolio, which also justifies the relevance of the work.

Figure 1. Organizational and managerial structure of a development company.

The aim of the article is to develop an algorithm for selecting a technology portfolio at the pre-investment stage of a commercial real estate project that will allow you to determine the most effective portfolio composition with high accuracy, to realize an object with high quality, and will also contribute to increasing the investment indicators of the project as a whole. To develop the algorithm, it is necessary to solve the following tasks:

1. To identify problems in the implementation of commercial real estate projects.
2. To identify the technological factors affecting the main indicators of the project.
3. To develop a methodology for forming a technology portfolio based on qualimetric methods.
4. To develop an algorithm for forming a technology portfolio of the project.

2. Methods
To develop a methodology we used the following research methods:

- theoretical analysis;
- comparison;
- questionnaire;
- system analysis;
- classification.
The scientific novelty of the study is to develop a system of criteria for the technology portfolio formation. The practical significance lies in the development of an algorithm that can be applied by companies in the implementation of investment and construction projects of commercial real estate. To solve this goal, the authors developed a research algorithm, which can be seen in Figure 2.

According to [17], project management functions are divided into:
- goal management;
- time management;
- cost management;
- quality management;
- risk management;
- contract management;
- personnel management;
- management of interconnections and information flows.

The authors have developed a methodology for forming a technology portfolio based on qualimetric assessment and the method of linear convolution. In this article, according to the author's decision, factor spaces are formed on the project management general regulatory basis: cost, time and quality.

The first step is to compile tables that compare technological solutions, which, in turn, are formed by analyzing market offers, relevance, and innovativeness and so on. Based on the analysis of the construction technology market, the authors made the assumption that the number of options varies from two to five.

The second stage is the formation of a factor space for further evaluation of technological solutions. Only the main factors that significantly affect the indicators of the investment and construction project are considered, their number is strictly limited and meets the requirements of project documentation [18]. When considering technological solutions the factor space is formed of the following factors:
- design factors;
- architectural and planning decisions;
- landscaping solutions;
- engineering solutions;
- organizational and technological solutions.
At the third stage, the weightings of the factor space individual components’ are determined by conducting questionnaires in a professional environment. When questionnaires, respondents are asked to evaluate the factors that influence a particular technological solution. Evaluation is carried out on a 100-point scale with an interval of 10%. Experts’ survey results processed using modern scientific tools that can reduce the assessment subjectivity and determine the importance of each criterion. An example of a survey is shown in table 1.

Table 1. An example survey in determining the significance technological factor facade systems evaluation.

| Design parameters | Response rate on a 100-point system with an interval width of 10% |
|-------------------|---------------------------------------------------------------|
| points            | 10  20  30  40  50  60  70  80  90  100                     |
| Percent           | 15  5  25  20  10  5  0  0  0                                 |
| Cumulative percentage | 15  20  45  65  85  95  100  100  100  100                  |
| Grade point average | 37,50                                                        |
| The coefficient of variation | 23,85                                                        |
| The allowable range with respect to the predetermined width | 30,00 – 50,00                                                  |
| Mean              | 40,00                                                         |

The fourth step is the qualimetric assessment of specific technological solutions. The comparison is made by types of technological solutions. Variants of solutions by categories are assigned quality characteristics. Qualitative characteristics, in turn, are assigned quantitative indicators. The authors developed a universal rating scale, which is given in table 2.

Table 2. Qualimetric scale for evaluating technological solutions.

| Quality characteristic | Quantitative indicator |
|------------------------|------------------------|
| Good                   | 1                      |
| Satisfactory           | 0.5                    |
| Poor                   | 0.1                    |

The appropriateness assessment of including a solution in a technology portfolio is determined according to the formula 1 developed by the authors.

\[ T_{pi} = \sum_{i=1}^{n} p_i \times \left( 1 - \frac{A}{100} \right) \]  

Where \( T_{pi} \) - priority coefficient inclusion of alternative technological solutions in the portfolio of investment and construction project; \( p_i \) - quantitative indicator of the weight of an alternative technological solution by the i-th factor; A - rating assigned to the i-th factor by respondents.

At the final stage, a common factor space is formed based on a comparison of technological solutions, based on which a technology portfolio is selected.

3. Results
Technological solutions are directly interconnected with architectural and constructive, since the characteristics of the latter affect the efficiency of technological processes. The final refinement of architectural solutions is carried out only after the full coordination of technological solutions, by
which is meant a set of measures to bring the architectural, space planning, design and engineering concepts in line with the function of the building and the technological process implemented in the building projected [19].

Typically, the calculation of the number and qualification of personnel, the number of jobs, the justification of the technological scheme, etc., is carried out directly by the design organization. In turn, the development company, at the suggestion of the authors of this article, provides the project organization with a technology portfolio developed at the conceptual stage as part of strategic planning so that all the design decisions would be made are justified, optimal and efficient [20].

Testing of the methodology developed by the authors and its results are systematized in the form of tables. The survey results and determining weighting the individual components are shown in Tables 3 and 4 for planning offices and facade system. The results of the factor comparison are presented on the example of architectural-planning and structural solutions presented in tables 5, 6.

Table 3. Weighting factors of the office planning decisions.

| Factor                  | Useful area | Air conditioning difficulties | Cost-effectiveness | Comfort |
|-------------------------|-------------|-------------------------------|--------------------|---------|
| Questioning Results, point | 80          | 40                            | 70                 | 60      |

Table 4. Weighting factors of the facade systems.

| Factor          | Fitting into the surrounding buildings | Maintainability | Labor input, installation on 1 m² | The cost of manufacturing, installation per 1 m², rubles | Impact on prestige |
|-----------------|----------------------------------------|-----------------|----------------------------------|--------------------------------------------------------|-------------------|
| Survey results, point | 60                                     | 50              | 40                               | 70                                                      | 60                |

Table 5. A comparison of the office layouts types.

| Type of office layout | Useful area | Air conditioning difficulties | Cost-effectiveness | Comfort |
|-----------------------|-------------|-------------------------------|--------------------|---------|
| Cabinet type          | 0.1         | 1                             | 0.1                | 1       |
| Combined type         | 0.5         | 0.5                           | 0.5                | 0.5     |
| Open Space            | 1           | 0.1                           | 1                  | 0.1     |

Office space “cabinet type” is characterized by the fact that the entire space of the room is divided into a room or rooms, and is assumed to use one or two or more employees. The presence of partitions greatly reduces the usable area of the room; therefore the factor “useful area” is assigned a quality indicator of “poor” or 0.1. For the indicator "cost-effectiveness" the same indicator is set, because the cost of arranging an office of this type is much higher in comparison with the concept of "open-space". The concept of the latter is that almost all employees are in one large room, separated by small furniture partitions, therefore, the category “useful area” is assigned a quality indicator of “good” or 1. But premises of this type are difficult to maintain temperature and air conditioning. The “combined type” combines several types of planning decisions.
Table 6. Comparison of facade system solutions.

| Facade systems          | Fitting into the surrounding buildings | Maintainability | Labor input, installation on 1 m² | The cost of manufacturing, installation per 1 m², rubles | Impact on prestige |
|-------------------------|----------------------------------------|-----------------|-----------------------------------|--------------------------------------------------------|-------------------|
| Ventilated Glass (stained glass) | 1                                      | 1               | 0.1                               | 1                                                      | 1                 |
| Brick cladding          | 0.1                                    | 0.5             | 1                                 | 0.1                                                    | 1                 |
| Plastering              | 0.5                                    | 0.1             | 1                                 | 0.5                                                    | 0.5               |

In the center of the city, the desired facade concept cannot always be realized due to the inability to fit into the surrounding buildings, so an appropriate factor has been added to the table. For example, in Moscow, facades are usually ventilated, with ceramic panel lining. This decision is relatively cheap and provides high-class building. From the point of view of installation speed and from an aesthetic point of view, it is recommended to use a stained-glass facade system, but in this type it is more difficult to observe the temperature regime. In addition, this facade system is the most expensive.

4. Discussion

The algorithm can be used by the developer organization to reduce costs in the implementation of investment and construction projects, and improve the quality of the finished object.

Based on the study, the following decision-making strategy can be built:
1. Formation multivariate space and determining weighting factors.
2. Quantification of technological solutions.
3. Comprehensive solution assessment. As an evaluation criterion, we take the priority coefficient.
4. Choosing one of three possible solutions.

Based on the studies, an algorithm for forming a technology portfolio of the project was developed, Figure 3.

![Figure 3. An algorithm for forming a technology portfolio of the project at a conceptual stage, developed by the authors.](image-url)
Testing the use of the algorithm developed by the authors is presented in the form of calculating a system of equations for a facade system:

\[
T_p = \begin{bmatrix}
1.0 \cdot \left(1 - \frac{60}{100}\right) + 1.0 \cdot \left(1 - \frac{50}{100}\right) + 0.1 \cdot \left(1 - \frac{40}{100}\right) + 1.0 \cdot \left(1 - \frac{70}{100}\right) + 1.0 \cdot \left(1 - \frac{60}{100}\right) \\
0.1 \cdot \left(1 - \frac{60}{100}\right) + 0.5 \cdot \left(1 - \frac{50}{100}\right) + 1.0 \cdot \left(1 - \frac{40}{100}\right) + 0.1 \cdot \left(1 - \frac{70}{100}\right) + 1.0 \cdot \left(1 - \frac{60}{100}\right) \\
1.0 \cdot \left(1 - \frac{60}{100}\right) + 0.5 \cdot \left(1 - \frac{50}{100}\right) + 0.5 \cdot \left(1 - \frac{40}{100}\right) + 0.5 \cdot \left(1 - \frac{70}{100}\right) + 0.5 \cdot \left(1 - \frac{60}{100}\right) \\
0.5 \cdot \left(1 - \frac{60}{100}\right) + 0.1 \cdot \left(1 - \frac{50}{100}\right) + 1.0 \cdot \left(1 - \frac{40}{100}\right) + 0.5 \cdot \left(1 - \frac{70}{100}\right) + 0.1 \cdot \left(1 - \frac{60}{100}\right)
\end{bmatrix} = \begin{bmatrix}
1.66 \\
1.56 \\
1.3 \\
1.04
\end{bmatrix}
\]

Based on the developed and tested algorithm, we find that it is advisable to include a ventilated facade system in the portfolio.

5. Conclusions

According to the results of the study, it was found that the lack of an optimal technology portfolio at the pre-project stage leads to problems at the investment and post-investment stages, including the need for amendments and changes to the investment and construction project during the construction process, entailing additional costs. The development of an algorithm for forming a technology portfolio of the project at the pre-investment stage avoids additional costs.

The article has been specified set of technological factors affecting the main indicators of investment and construction project. On their basis, a methodology for forming a technology portfolio based on qualimetric methods was developed. An algorithm for forming a technology portfolio was also developed.

The practical significance of the proposed approach lies in the fact that its application is another step in the project quality control system, and also allows you to reduce part of the costs and risks of the investment construction project.

The novelty of the study lies in the developed approach to the projects technology portfolio formation in the implementation of commercial real estate using complex indicators. The results obtained in the article make it possible to obtain a project technology portfolio that serves as additional input for a design organization, allowing it to develop a set of design documentation without the need for a significant change at the construction stage. In conclusion, it should be noted that as part of the development of a scientific idea, the authors propose to conduct a number of additional studies in order to clarify the proposed decision-making approach for choosing a portfolio of technologies for a commercial real estate development project.

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