UDC 69.003

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Application of the economic–mathematical model to determine the efficiency of residential renovation projects and to choose the optimal strategy for their implementation

Implementation of the residential renovation programme is one of the most important programmes aimed at improving the socio-economic well-being of the Russian regions. The implementation of this programme involves the restoration and renovation of existing residential buildings in order to provide citizens with comfortable and safe housing conditions. In order to reduce the number of emergency and dilapidated dwellings, a set of measures is envisaged to restore the technical condition, reduce physical deterioration or, if restoration is not feasible, to carry out works on liquidation of existing dwellings and implementation of new construction projects. The experience of the residential renovation programme in the Moscow region, where the programme has been in effect since 2017, shows that the choice of project implementation strategy does not always fully take into account all the initial parameters of the land plot or object included in the targeted renovation programme. This peculiarity may lead to a decrease in the efficiency of project implementation and increase the risk of project cost increase, increase in construction time and other negative consequences.
Due to the fact that the residential renovation programme is implemented at the expense of the federal budget, and the programme assumes timely planned wave resettlement of citizens, the reduction of the probability of occurrence of a delay in the implementation time and exceeding the initial budget are among the most significant negative aspects in the implementation of the residential renovation programme. In order to assess the initial parameters of the objects, as well as to determine the resulting efficiency of the project, the application of the economic-mathematical model will allow to sufficiently form a number of estimated parameters that are of the greatest importance for the renovation projects being implemented, to analyze them and on their basis to calculate the resulting indicator of the project efficiency, which will subsequently form the basis for determining the most optimal strategy of the project implementation, taking into account its characteristics.
Keywords: *residential development renovation programme, integrated territorial development, economic and mathematical modelling, Moscow City Renovation Programme*

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The development and application of economic and mathematical models is directly related to efficiency assessment. When considering the construction industry, the assessment of project efficiency can be carried out when considering organizations, management methods, implementation of construction projects. The development of an economic-mathematical model implies, among other things, the assessment of parameters and factors that determine a particular object (organization, construction project and so on). The main task of applying an economic-mathematical model is to consider the processes, as well as interrelated with them initial parameters and factors that affect the efficiency of the processes, which can be determined on the basis of the calculated resulting indicator.

The development of economic and mathematical model is carried out by applying the method of system analysis[1]. The analysis allows determining the processes to be evaluated, as well as the factors that have the greatest influence on them. Application of the method of system analysis allows to evaluate processes that involve a large number of initial parameters. This method allows to evaluate factors when considering from general to particular, which differs from the inductive approach. Application of the system approach within the framework of building an economic-mathematical model makes it possible to evaluate and analyze all the factors affecting the subject under consideration at all stages of system research and building its model. The system approach means that each system is an integrated whole even when it consists of heterogeneous subsystems[2].

The use of the system approach in building an economic and mathematical model under a large number of initial conditions also requires determining the necessary amount of control information in the real system, estimation of the considered indicators. This method will subsequently allow us to determine the most effective variant of construction and the optimal mode of functioning of the model[1, 3].

The content of the modelling method is the construction of the model on the basis of preliminary study of the object and selection of its essential characteristics, experimental or theoretical analysis of the model, comparison of the results with the data on the object, adjustment of the model resulting — efficiency. In this regard, economic and mathematical models describing the impact of

1 Programme for Renovation of Housing in the City of Moscow : Decree of the Government No. 497-PP.
2 Consideration of Public Opinion on Housing Renovation Project in Moscow : Decree of the Government No. 245-PP.
3 Approving the Addressed List of Neighbourhoods (Territories) : Government Decree No. 708-PP.

individual factors (parameters) on the final results of enterprises (objects) are used[4].

Additive computational model has linear constraints:

$$q = \sum_{i=1}^{n} a_i, \quad (1)$$

where n — number of analyzed parameters; a_i — weight of i — parameter.

The adaptive model under consideration is expressed as an algebraic sum of deterministic summands, which are the estimated factors affecting the performance of the assessed entity. In this regard, the adaptive model can be used only if the considered factors (summands in the algebraic sum) are represented and belong to a single economic nature[5].

Multiplicative models of economic and mathematical modelling are written as follows:

$$q = \sum_{i=1}^{n} a_i = a_1 + a_2 + \ldots + a_i, \quad (2)$$

where q is the resultant indicator; a_1, a_2 and so on — factors affecting the resultant indicator.

Thus, in multiple models, the resulting indicator is a relative value reflecting the ratio of factorial indicators. Most often multiple models are used to develop various ratios. When working with multiple models, it is necessary to take into account that although they allow calculating the ratio of factorial indicators that have different nature and dimensionality.

The basis for the construction of an economic-mathematical model that allows the evaluation and choice of strategy for the implementation of a particular project of renovation of residential buildings is the construction of the factor space, which can determine the basic initial parameters of the considered object in order to select the most appropriate strategy and will allow a more accurate calculation using the developed economic-mathematical model[4, 5] [1].

In order to carry out further calculations to determine the efficiency of the land plot considered for construction and within the framework of building an economic and mathematical model, it is necessary to determine the limit values for each of the parameters under consideration, which should subsequently serve as a basis for calculating the resulting indicator for the assessment of the land plot under consideration and the subsequent choice of the project implementation strategy based on the calculation. For this purpose, it is proposed to determine the limit values of the parameters under consideration on the basis of the minimum and maximum values of each of them [2].

Thus, after determining the factors, it is possible to assess the land plot under consideration for the construction of a residential building within the framework of the residential renovation programme and to determine the efficiency of the land plot use. Also, the proposed assessment of the land plot according to the factors described above will allow further analysis in order to choose the most optimal strategy for the implementation of the residential renovation project [2, 3]. Based on the obtained values of the resulting indicators of project efficiency, the efficiency of the planned for implementation project of residential development renovation will be determined.

The construction of economic-mathematical model is a universal mechanism that allows to make a calculated assessment of the initial data of the project. The result of building an economic-mathematical model should be a calculated index of project efficiency, varying in the range of certain and individual values [2, 4]. As part of the application of the economic-mathematical model, each evaluated project should receive a calculated efficiency index, which will subsequently serve as a basis for choosing a project implementation strategy.

Thus, it is logical to assign additional indices and symbols to the factors and parameters, namely: the initial parameters of the object are determined by the parameter a_n, the project performance indicators are determined by the value f_n, where f is the calculated value based on the assessment of the initial parameters.

In order to more accurately calculate the final indicators of project efficiency, it is proposed to introduce the following formula for calculating the forecast indicator of the evaluated factor:

$$\Delta f_{1\max} \cdot (100\ \% - a_1), \quad (3)$$

where f_1 is the value of the evaluated performance indicator; a_1 is the value of the initial parameter of the project.

$$k_{calc} = \left(1 + \frac{\left(a_{n\max} - a_{nfact}\right)\left(k_{\max} - k_{\min}\right)}{\left(a_{n\max} - a_{n\min}\right)}\right). \quad (4)$$

In order to add the values of the initial parameters of the evaluated project, it is suggested to use the method of interpolation, thanks to which it is possible to evaluate all kinds of parameters in different values on a single evaluation scale. Then, the parameter will be rationally defined by the following calculation formula:
where k_{calc} — estimated estimator of the estimated parameter; $a_{n\max}$ — maximum estimated value of the parameter (determined empirically); a_{nfact} — actual values of the estimated parameters; $k_{\max}$ — maximum estimated value of the parameter; $k_{\min}$ — minimum estimated value of the parameter; $a_{n\min}$ — estimated value of the parameter (determined empirically).

It is proposed to use the above formula when calculating each actual a_n parameter as part of the evaluation of the project under consideration [5]. Evaluation of the forecast indicator will show the calculated percentage deviation of the maximum (best project indicators) indicators of project efficiency and will allow to determine the forecast value of the efficiency indicator, which, in turn, will help in the construction of economic and mathematical model to calculate the resulting indicator of project efficiency [4, 5].

To assess each parameter, it is proposed to use a scale from 1 to 100. To obtain the value for each of the parameters, an interpolation method is used depending on the value in the range of values for each parameter being evaluated.

The formula for assessing the effectiveness of each separately taken parameter is defined can be presented in the following general form:

$$K = \sum_{i=1}^{n} P_i K_i, \quad (5)$$

where K — evaluation coefficient of parametric efficiency of the project; P_i — evaluation weighting coefficient of the evaluated parameter; K_i — efficiency coefficient of the evaluated parameter.

4 Approval of the Basic Requirements to Improvement of the Residential Development Territory during the Implementation of the Programme for Renovation of the Residential Stock in the City of Moscow : Government Decree No. 515-PP.

5 Approval of the Requirements for Improved Finishing of Equivalent Residential Premises Provided in Replacement of Residential Premises in Multifamily Buildings : Government Resolution No. 516-PP.

In order to calculate the estimated indicator of project efficiency, which is dependent on a certain initial factor with the reduction of this indicator to a single evaluation scale, it is proposed: based on the efficiency coefficient of the renovation project obtained by the calculation method, it is possible to determine the possible and most effective strategy adopted for the implementation of the project [6, 7]. The choice of the project implementation strategy is made taking into account the calculated project indicator K and on the basis of the project baseline data, which are individual for each of them. Determination of the exact estimation of each parameter takes place using the interpolation method within the specified range [8]. This value is proposed to be determined as follows using the estimated formula:

$$y = \left(1 + \frac{\left(a_{nfact} - a_{n\min}\right)\left(k_{\max} - k_{\min}\right)}{\left(a_{n\max} - a_{n\min}\right)}\right), \quad (6)$$

where y — calculated estimated indicator of the estimated parameter; a_{nfact} — actual values of the estimated parameters; $a_{n\min}$ — minimum estimated value of the parameter (determined empirically); $a_{n\max}$ — maximum estimated value of the parameter (determined empirically); $k_{\max}$ — maximum estimated value of the parameter; $k_{\min}$ — minimum estimated value of the parameter (from 1 to 100).

In turn, the estimated value of the estimated parameter of project efficiency is proposed to be determined by the following formula:

$$\Delta f_{n\max} = \left(f_{\max} - f_{\min}\right)t, \quad (7)$$

where $\Delta f_{n\max}$ — absolute maximum deviation by indicator; $f_{\max}$ — maximum estimated value of the evaluated indicator; $f_{\min}$ — minimum estimated value of the estimated indicator; t — coefficient of influence of the considered factor on the estimated indicator.

Then, the estimated projected project performance indicator will be presented in the form of:

$$\Delta f_{ncalc} = \Delta f_{n\max}(100\,\% - y), \quad (8)$$

where Δf_{ncalc} — estimated value of the assessed indicator in absolute values.

Based on the above developed formulas for calculating actual and forecast indicators of project efficiency, it seems possible to form a formula for calculating the resulting coefficient of project efficiency, which will be able to show a universal value, showing the effectiveness of the project based on the values obtained:

$$K_{calc} = \sum_{i=1}^{n}\left(1 + \frac{\left(f_{1calc} - f_{1\min}\right)\left(k_{\max} - k_{\min}\right)}{\left(f_{1\max} - f_{1\min}\right)}\right)k_i. \quad (9)$$

Consequently, combining the above, the general calculation formula can be summarised as follows:

$$K_{calc} = \sum_{i=1}^{n}\left(1 + \frac{\left(\left(f_{\max} - f_{\min}\right)t\right)\cdot\left(100\,\% - \left(1 + \frac{\left(a_{n_{fact}} - a_{n_{\min}}\right)\cdot\left(k_{\max} - k_{\min}\right)}{\left(a_{n\max} - a_{n\min}\right)}\right) - f_{n\min}\right)\left(k_{\max} - k_{\min}\right)}{\left(f_{1\max} - f_{1\min}\right)}\right)k_i. \quad (10)$$

After parameter estimation is determined, the project indicator is calculated according to the specified formula in order to find the exact value corresponding to one of the specified ranges for the choice of strategy for the implementation of the residential renovation object, which, in turn, determines the set of methods and means necessary to improve the overall efficiency of the project [9, 10].

In order to build an economic-mathematical model for projects implemented within the framework of the renovation programme, it is necessary to develop a mechanism for parameter estimation. The initial parameters will help to assess the potential of the project and the degree of risks in its possible implementation [9, 11, 12].

The main objective is to reduce the level of risks in order to increase the efficiency of implementation of residential renovation projects. According to the author's conclusion, the application of the economic-mathematical model of choosing the most optimal strategy for the implementation of the residential renovation project contributes to the reduction of the risk level, which can increase the predictability of the object, as well as reduce the probability of exceeding the established terms of the project implementation and exceeding the established budget, and thus increase the overall efficiency of the implementation of residential renovation projects.

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Применение экономико-математической модели с целью определения эффективности проектов реновации жилой застройки и выбора оптимальной стратегии их реализации

Реализация программы реновации жилой застройки является одной из важнейших программ, ориентированных на улучшение социально-экономического благосостояния регионов Российской Федерации. Реализация данной программы предполагает восстановление и обновление сложившейся жилой застройки с целью обеспечения граждан комфортными и безопасными жилищными условиями. С целью сокращения количества аварийных и ветхих жилых домов предусмотрен комплекс мер по восстановлению технического состояния, сокращению физического износа или в случае, если восстановление не является целесообразным, то проведение работ по ликвидации существующих жилых домов и реализации проектов нового строительства. Опыт реализации программы реновации жилой застройки на территории московского региона, где данная программа действует с 2017 г., показывает, что выбор стратегии реализации проекта не всегда в полной мере учитывает все исходные параметры, которыми обладает земельный участок или объект, попадающий в адресную программу реновации. Данная особенность может приводить к снижению эффективности реализации проекта и повышению рисков увеличения стоимости проекта, увеличению сроков строительства и иным негативным последствиям.

В связи с тем, что программа реновации жилой застройки реализуется за счет федерального бюджета, а также программа предполагает своевременное планомерное волновое переселение граждан, то сокращение вероятности возникновения отставания в сроках реализации и превышение первоначального бюджета являются одними из самых существенных негативных аспектов при реализации программы реновации жилой застройки. С целью оценки исходных параметров объектов, а также определения результирующей эффективности проекта применение экономико-математической модели позволит в достаточной мере сформировать ряд оцениваемых параметров, которые представляют наибольшую значимость для реализуемых проектов реновации, провести их анализ и на их основе сформировать расчетным образом результирующий показатель эффективности проекта, который впоследствии ляжет в основе определения наиболее оптимальной стратегии реализации проекта с учетом его особенностей.

Ключевые слова: *программа реновации жилой застройки, комплексное развитие территорий, экономико-математическое моделирование, программа реновации города Москвы*

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For citation: Kirpichenkov A.A. Application of the economic-mathematical model to determine the efficiency of residential renovation projects and to choose the optimal strategy for their implementation. *Real Estate: Economics, Management.* 2024; 2:61-64.

Для цитирования: *Кирпиченков А.А.* Application of the economic-mathematical model to determine the efficiency of residential renovation projects and to choose the optimal strategy for their implementation // Недвижимость: экономика, управление. 2024. № 2. С. 61–64.