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Master in Corporate Finance

Evaluation of investment projects in the construction industry under extreme uncertainty

Master's Thesis by 2nd year student
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ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

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I, Rochev Grigoriy, second year master student, program «Corporate Finance», state that my master thesis on the topic “Evaluation of Investment Projects in the Construction Industry under Extreme Uncertainty”, which is presented to the Master Office to be submitted to the Official Defense Committee for the public defense, does not contain any elements of plagiarism.

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____ (Student’s signature)

_____________________________________30.05.2023______ (Date)

АННОТАЦИЯ

Автор	Рочев Григорий Сергеевич
Название магистерской диссертации	Оценка инвестиционных проектов в строительной отрасли при экстремальной неопределенности
Факультет	Высшая школа менеджмента
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Научный руководитель	Окулов Виталий Леонидович
Описание цели, задач и основных результатов	Инвестиционные строительные проекты часто сталкиваются с высокой неопределенностью. Девелоперские проекты в сфере жилой недвижимости обладают экстремальной неопределенностью. Она возникает из-за того, что мы не знаем, будет ли продана недвижимость в конкретный период времени или нет. Экстремальная неопределенность не позволяет применять традиционные методы оценки. Кроме того, в известной литературе отсутствует информация о подходах, позволяющих учесть высокую неопределенность. ООО «Центр управления проектами в ЖКХ» затрудняется оценить свой девелоперский проект «НЕО Сочи». Целью данного исследования является оценить строительный проект с экстремальной неопределенностью «НЭО Сочи» с помощью разработанного метода. Для достижения этой цели были проанализированы существующие методы, разработан и применен новый метод, собраны данные от Компании и проанализированы результаты. Неопределенность учитывается путем моделирования времени экспозиции недвижимости как редкого события с помощью экспоненциального распределения, а ожидаема чистая приведенная стоимость рассчитывается с помощью метода Монте-Карло. Результаты показывают, что положительный NPV будет достигнут с высокой вероятностью 99,75%, в то время отрицательный NPV будет достигнут с вероятностью менее 1%. NPV от 10 до 20 миллионов рублей имеет вероятность 24%, а NPV от 20 до 30 миллионов рублей имеет вероятность более 50%.
Ключевые слова	Экстремальная неопределенность, строительный проект, девелоперский проект, жилая недвижимость, время экспозиции

ABSTRACT

Master Student's Name	Grigory S. Rochev
Master Thesis Title	Evaluation of Investment Projects in the Construction Industry under Extreme Uncertainty
Faculty	Graduate School of Management
Major Subject	38.04.02 “Management”, Corporate Finance (MCF)
Year	2023
Academic Advisor's Name	Vitaly L. Okulov
Description of the goal, tasks and main results	Construction investment projects often faces with high level of uncertainty. Construction projects in residential real estate development have extreme uncertainty. It arises because we do not know whether real estate will be sold or not in particular period. Extreme uncertainty does not allow to apply traditional appraisal techniques. Also, there is a lack of discussion in well-known literature regarding an approach that deal with this uncertainty. As a result, LLC "Center for project management in housing and utilities" finds it difficult to evaluate construction development project «NEO Sochi». The goal of this research is to evaluate construction project with extreme uncertainty «NEO Sochi» by introduced method. To achieve this goal existing method was analyzed, new methodology based on NPV was developed and applied, data from Company was obtained, results was analyzed. Uncertainty is incorporated by modelling exposure time of real estate as a rare event by exponential distribution, final NPV is calculated using Monte-Carlo approach. The results show that positive NPV will be achieved with high probability 99,75%, while there is only a small chance of failure with a negative NPV of less than 1%. NPV between 10 and 20 million RUB has a 24% probability, while NPV between 20 and 30 million RUB has over 50% probability.
Keywords	Extreme uncertainty, construction project, development project, residential real estate, exposure time

Contents

Introduction

The construction industry plays a vital role in determining the economic development of the modern world and meeting the essential needs of society. In the context of rapidly changing economic and technological requirements, this industry faces a number of complexities and challenges associated with uncertainty and high risks. In a construction project, uncertainty can occur due to incomplete knowledge of project parameters, changes in market conditions, problems in the construction process, and other factors. Construction development projects often faces with extreme uncertainty that relates to revenue obtained from selling developed real estate. Extreme uncertainty arises because we do not know whether real estate will be sold or not in particular period of time, so if it is sold, we have positive cash flow, if not – cash flow is zero. Such uncertainty can significantly affect the profitability of the project and cause risks for investors. Although various investment appraisal methods are used for construction projects, there is a lack of discussion in well-known literature regarding an approach that can account for the significant uncertainty associated with construction development projects. From a scientific point of view, the question has not been worked out, but this approach has high practical importance.

In my Master thesis method based on NPV techniques for the evaluation of construction project with high uncertainty will be introduced. In context of Thesis, uncertainty will be considered in exposure time (time to sale) of residential real estate. Introduced method will be implemented on real construction development project. This project is «NEO Sochi» that is elite cottage village of 6 cottages with an area of 215 m2 in the village «Chereshnya», Adler district, Sochi. Project is performed by LLC "Center for project management in housing and utilities", the aim of this project is to build and sell 6 cottages. Obtained results will be compared with traditional investment appraisal method NPV and discussed. Company finds it difficult to evaluate the effectiveness of this project due to extreme uncertainty, so traditional NPV approach is not suitable. Therefore, there is a practical need for method that succeed in evaluation of construction project with extreme uncertainty.

The research gap I would like to fill is the following. The evaluation of construction projects with a high degree of uncertainty is an area that has been little explored in the literature. Although there are studies on the assessment and management of risks in construction, most of them assume that uncertainties can be quantified and that probabilistic methods can adequately reflect their impact on project outcomes. However, in scenarios where uncertainty is particularly high, traditional risk management techniques may not provide accurate estimates of the potential impact on project success. Thus, there is a need for research that explores alternative methods for evaluating construction projects that can take into account the high level of uncertainty. This research gap highlights the need for further exploration of new approaches to project appraisal that can address the extreme uncertainty in construction projects.

Research goal of this paper is to evaluate construction project with extreme uncertainty «Neo Sochi» by introduced method.

In order to answer the research question, the following objectives was set:

1. Analyze methods of investment appraisal used in practice for the evaluation of construction projects with high uncertainty
2. Introduce methodology based on NPV
3. Collect data from construction project with extreme uncertainty
4. Apply the proposed method for the construction project
5. Analyze the effectiveness of the investment project and provide practical recommendations

Method introduced has several managerial implications for investment projects in construction industry. First, it provides a more accurate and reliable method of evaluating the feasibility of investment projects under extreme uncertainty. Method provides valuable information that can aid managerial decision-making. One practical application of this method is that the company management can analyze the Net Present Values (NPVs) to make well-informed investment decisions and evaluate the probability of different project outcomes when faced with uncertainties. Second, it enables project managers to identify and manage risks more effectively, which can improve project outcomes. Third, the method yields information that can be utilized to determine the optimal selling price for individual cottages, thereby maximizing the NPV of the entire project, as well as identifying price thresholds.

Master thesis consists of Introduction, Chapter 1, Chapter 2, Conclusion, References and Appendix. Chapter 1 is devoted to literature review about theoretical aspects and methods of evaluation construction projects with extreme uncertainty. Chapter 2 is devoted to proposed methodology, description of chosen project, discount rate calculation, calculation of expected NPV, discussion of obtained results and practical recommendations. Conclusion summarizes the overall results of the Master Thesis. Reference part describes the list of literature used. Appendix is devoted to reference information for sensitivity analyses.

Chapter 1. Theoretical aspects of construction projects with extreme uncertainty

1.1 Basic concept of construction project

A construction project is a venture that encompasses the entire investment process of constructing a structure: starting from the initial investment of capital to reach the investment goal and successfully finish the proposed task. These projects involve investing money into building properties with the intent of generating profits in the future.

The goal of construction project is to generate a specific return on investment for the investor, maximize the benefits for investors. This can be accomplished through a variety of means, such as leasing the property to tenants, selling the property after construction is complete, or generating revenue from usage fees. To successfully complete the project and reach the desired outcomes, it is important to make the most of available resources while minimizing potential risks.

Each construction project has certain stages of development: pre-investment stage, investment stage and final stage. The pre-investment phase involves developing and agreeing on a design concept, comparing different options, creating and approving project proposals, preparing for construction, conducting feasibility studies, reviewing and approving the project plan, obtaining building permits, and outlining the business development plan for the project.The investment stage accounts for the high amount of investment. At this stage, most of the work on project implementation is carried out: organization of purchases and supplies (procurement of design and measurement works, supply of equipment, procurement works and conclusion of contracts), construction and installation works. In the final phase, the commissioning work is carried out and the completed building is handed over, the plant is used, i.e. the achievement of the final project goals and the synthesis of the results (Karavaeva et al., 2021).

Construction projects can vary in scope and size, from small renovation projects to large-scale developments. Construction projects can be divided into the following types: civil construction (residential buildings, office buildings, etc.), industrial construction (factories, factories, industrial plants, etc.), road construction (roads, sidewalks, landscaping, etc.), special construction (military facilities, power plants, spaceports, airports and other specialized facilities). Depending on the duration, construction projects are divided into the following types: short-term (less than 6 months), medium-term (from half a year to 1 year), long-term - more than 2 years. Based on the type of financing, construction projects are divided into: budget (financed by budgets), commercial (financed by private companies and individuals), mixed (Bovteev, 2013).

Among the various types of investment construction projects, development projects are widespread. Development is a business activity related to the construction or reconstruction of an existing building or property that results in an increase in its value. Developer is usually legal entity, that have the opportunity to attract large investments under development of their projects.

The developer is responsible for overseeing an investment project in which the goal is to reduce risks while increasing profits. This involves conducting an in-depth investment analysis of the project, planning and designing future facilities, creating a budget, attracting potential investors, and ultimately selling the project.

Development project can be realized in the following ways. The first is speculative. Developer here is the initiator of the project and assumes the risk of project failure. Construction is carried with the participation of credit funds. The developer carries out the planning, the necessary office permits, the construction and the handover of the premises at his own expense. It attracts specialists for all the necessary work. Another type of development project is fee development. Developer here is just employee and bears no financial risk and receives a fixed fee for his work. In this case, developer works for a fee from the owner for rent, builds and manages the facility on behalf. Participation in the project takes place without the use of own funds, the project is sponsored by the investor or financed by the bank. BTS is other type of development in construction, which involves the creation of real estate objects for the specific needs and requirements of the customer. The main idea of BTS is that there is a customer who already has a ready business plan and project, and only needs to build a property that will meet his requirements. In this case, the customer usually rents or buys a finished object, which makes the development process riskier for the investor (Mazur, 2010).

Moreover, depending on type of property development projects can be divided into the following groups (Selina, 2014):

- «Residential real estate development
- Commercial real estate development
- Land development
- Office real estate development
- Industrial real estate development and others».

The fundamental goal of development project is to generate income by creating objects that meet the needs of real estate buyers. The development should result in the emergence of a new real estate object that meets the needs of business and the population in terms of its characteristics (Dyukova, Pasyad, 2009).

When evaluating the effectiveness of investments in a development project, one should take into account an important feature, which is the requirement for high returns combined with significant risks and extreme uncertainty. Extreme uncertainty refers to situations where there are significant unknowns or risks that could impact the outcome of the project. Various factors such as buyer behavior, real estate pricing, complex designs, extreme weather, political factors, or unforeseen circumstances during construction can contribute to high levels of uncertainty. Extreme uncertainty can be challenging to manage, and it requires careful planning and analysis to identify potential risks and develop strategies for addressing them.

1.2 Methods for evaluation of construction projects

Assessing investment proposals within the construction sector is a crucial responsibility for investors, construction firms, and governmental bodies. Investment appraisal methods are crucial in determining the feasibility and profitability of any investment project. Essentially, investment appraisal is the process of evaluating the financial viability of a potential investment project.

The attractiveness of an investment project can be determined through various factors and standards such as the condition of the investment market, the financial market circumstance, the investor's personal interests and professional capabilities, the capacity to fund the project, overall circumstances, the geopolitical climate, and others. However, in practice, there are universal methods of assessing the investment attractiveness of projects, which give a formal answer: is it profitable or unprofitable to invest in this project, which project to give preference to when choosing various options (Kosov, 2017).

Depending on the consideration of the time factor in the evaluation of investment projects, the criteria and methods of evaluation are divided into the following groups:

1. Static methods
2. Methods based on discounting

The initial indicators are assigned specific, unchanging values by the first group. Their application does not account for the project's complete life span or the uneven cash flows that happen at various times in time. These techniques are common, despite being mostly employed for quick evaluation of projects at the early phases of development, due to their simplicity and illustrative nature. Furthermore, these techniques grant a chance to make computations using financial information. (Gilemkhanov, Braila, 2017).

The techniques incorporated in static methods are payback period, net value, and accounting rate of return.

Payback period, also known as PP, refers to the duration taken by a newly established or renovated company to recover its investments from the earnings produced by its business activities. The indicator's purpose is to estimate how long it will take the investor to be able to get their money back. This method uses only static data and non-discounted values for calculating and ignores depreciation, tax burden, and inflation. To determine the payback period for investments, the payments received are added together on an accrual basis to form the cumulative cash flow balance. The frequency of dividing the project's life into planning intervals has a significant impact on the accuracy of the method for evaluating effectiveness that is currently being used. The payback period is the planning interval in which the cumulative cash flow balance becomes positive:

$$PP = \min t, \quad \text{when } \sum CF_t \geq \sum C_o$$

Where:

CF_t – cash flow from project in year t,

C_0 – Initial investments.

However, this indicator has several drawbacks, including its failure to consider fluctuations in cash flow costs over time, inability to determine post-payback cash flow amounts, and difficulty in calculating payback periods for sign-variable cash flows. Another major issue is that it only focuses on activities within the payback period, making it unsuitable for comparing projects with different implementation timelines. Additionally, it does not account for changes in cash values over time or the possibility of reinvesting income (Dai et al., 2022).

Net value, NV is techniques is to find the sum of all outflows and inflows of cash flow implemented by the investment and construction project. This method is often used in short-term projects to analyze liquidity and solvency .Net value can be calculated according to the following formula:

$$NV = \sum_{t=0}^{n} CF_t - \sum_{t=0}^{n} C_0$$

However, this method has some disadvantages. Drawbacks include the estimate's low accuracy, the method's lack of consideration for the amount invested and the degree of reinvestment (investing created profits back into the project), and its failure to account for changes in the value of money over time. As a result, this approach is used in short-term projects, which is unusual for the construction industry (Gilemkhanov, Braila, 2017).

Accounting Rate of Return, ARR is a financial metric used to evaluate the profitability of an investment project. ARR is the average annual income generated by an investment in construction, expressed as a percentage of the initial investment. This metric is commonly used to evaluate the potential profitability of a project before making investment decisions. A higher accounting rate of return indicates a more profitable investment opportunity. The accounting rate of return is estimated by dividing the average annual income by the initial investment cost:

$$\text{ARR} = \frac{\text{AAI}}{C_0}$$

Where:

AAI – average annual income.

However, it is important to note that the ARR has some limitations. Firstly, it ignores time value of money which means that it does not take into account the fact that money has different values at different times. The second limitation of ARR is that it neglects cash flows and focuses solely on accounting profits, failing to consider the importance of cash flow in assessing the effectiveness of an investment project. Thirdly, it ignores risks associated with an investment project, such as inflation, market fluctuations, or changes in regulations. Also, ARR has no benchmark, which makes it difficult to compare the performance of an investment project with other similar projects (Konstantin, 2018).

Thus, static methods for evaluating investment projects, along with advantages (simplicity of calculation and illustrative nature), have a number of significant drawbacks. The key one is that different values are used for calculations—the amount of investment in present value and profit in future value and the time component is not taken into account. The techniques disregard the reality that identical receipts or payments over various time periods do not have a same value. This aspect must be understood and taken into account in order to properly evaluate projects involving long-term capital investments. By overestimating the payback period and underestimating the efficiency factor, this drastically skews the computation findings (Kosov, 2017).

Second group - methods based on discounting, is more complex and must consider a wide range of aspects. They are typically used to assess long-term investment projects that want extra funding for implementation. The search for discount rates that enable you to bring income and costs to values close to real is a crucial step when utilizing dynamic methods. Discounting is the process of transforming a cash flow's future value into its present value. The cost of all potential sources of investment capital, inflation, and potential risk indicators must all be considered when determining the discount rate.

Methods based on discounting include the following techniques: Net present value, Internal rate of return, Discounted payback period, Profitability index etc.

The net present value method is considered the main and most common, as it allows to compare projects with different durations and capital investments. The NPV serves to compare the expenses required for executing a project with the present value of potential future cash receipts. Its computation is based on the unique time value of money, and the value is determined using the discounting technique. The net present value represents the contrast between the preliminary investments and the discounted values of the inflows and outflows of cash produced by the undertaking's construction project throughout the specified period. (Brealy et al., 2014):

$$NPV = -C_o + \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t}$$

Where:

CF_t- cash flow in a period of t year (all financial receipts and expenditures),

C_o is the initial investment, usually a negative value,

r – discount rate.

A positive NPV value is regarded as evidence that investing money in a project is a wise decision, while a negative value, on the other hand, shows that using that money is a wasteful use of resources. Moreover, for multiple alternative projects: the project with the higher NPV is accepted, provided it is positive.

Selection of a discount rate has a significant impact on calculation NPV. If the discount rate increases, the NPV value decreases. Rejecting a project based solely on a negative NPV is not always justified since profitability is the primary criterion for effectiveness. If a project is profitable but has a negative NPV, it is advisable to reconsider the discount rate, which may be objectively overestimated. Otherwise, it is likely that the decision to reject the investment is correct, since the project does not provide a return on investment (Huang et al., 2022).

One of the advantages of NPV is that it allows to calculate the economic effect obtained immediately after the decision to implement this project. Moreover, NPV takes into account the change the time value of money. Also, this method has the additivity property, which enables one to create the investment portfolio by combining the NPV figures from multiple investments (Dai et al., 2022).

However, NPV has some disadvantages. The first is calculation of NPV is based on one target function – the cost of funds. The second is calculation demand fixed period of project implementation, that is difficult to obtained in practice. The third is CF need to be assigned to certain period, but in practice cash flows are chaotic (Huang et al., 2022). Moreover, net present value assumes that the discount rate remains constant for all period, but in practice interest rates may change over time. Also, NPV does not take into account the possibility of reinvesting the generated profit. Moreover, construction projects are characterized by a high degree of uncertainty, that can be arise from high uncertainty in future price of object of construction, unexpected changes in time to sale, unexpected delays in the construction process, changes in market conditions etc, so NPV requires a deep analysis of the degree of uncertainty (Armeanu, Lache, 2009).

The second method is IRR. The IRR represents the discount rate that equates the present value of inflows with the present value of outflows, resulting in a net present value of zero. This basically means that the IRR is the breakeven point for a project. Investors aim to achieve a high IRR, as it indicates a better rate of return. A project is considered feasible if its IRR is equal to or greater than the base rate of return.

The economic importance of the indicator lies in its ability to depict the highest expense that can be borne by the building project without causing financial losses. In the case of bank-financed construction, the IRR serves as the maximum percentage at which the project turns unprofitable. The project's creator receives funding from a variety of sources. As well as having a value that is indicated as a percentage or dividends paid to the owner of the borrowed funds, each financial source used to fund a construction project has its own worth. As a result, the developer is responsible for paying to maintain its economic potential (Gilemkhanov, Braila, 2016).

The project is approved if the IRR exceeds or is equivalent to the cost of capital. The project is abandoned if the IRR is negative relative to the cost of capital. IRR functions as a barrier indication in this way: if the cost of capital is higher than the IRR value, the project should be rejected because it lacks the "capacity" to generate the required profitability and return on investment (Patrick M, French, 2016).

One of the advantages is that IRR can be used to evaluate the desirability of projects and reflects their profitability. This makes it easy for management to maximize profits by choosing the project with the highest IRR that's greater than the hurdle rate. Comparing the IRR to the hurdle rate is a common practice that shows IRR is the maximum interest rate that can be paid to repay a loan and still make a profit (Mellichamp, 2017).

However, IRR has some disadvantages. First, to use IRR effectively, it is necessary for the payment streams to be of a flat and annuity type. If the cash flows are unconventional, meaning they do not follow a predictable pattern, there may be multiple or no results when using IRR. In these cases, the use of IRR does not hold any economic significance (Biacino, Simonelli, 1991).

In addition, the IRR might not effectively show how profitable an investment project is since it is not measured in units and can be deceptive. This means that if the initial cost is lower than the point where returns equal expenses, a project with a lower IRR could have a greater net present value. (Jiang, 2008).

Based on the above, traditional investment appraisal techniques has significant drawbacks and cannot be used for evaluation of construction projects with extreme uncertainty. Thus, let’s consider some modern techniques that perhaps can deal with uncertainty problem.

One approach that has been proposed for evaluating construction projects with high uncertainty is decision tree analysis. By creating a graphical representation of the decision-making process, decision tree analysis enables the representation of all potential outcomes and their probabilities. Decision-makers can choose the best option and comprehend the costs and advantages by using this graphical representation. Study by Chen et al. (2022) show that decision tree analysis can significantly improve the accuracy and reliability of project evaluations under high uncertainty.

However, the decision tree method has significant drawbacks. The first is limited applicability. For issues with discrete and categorical inputs and outputs, decision trees work best. They might not be appropriate for assessing building projects that require continuous and sophisticated data, such as complex building codes, geological data, or weather patterns. The second is complexity. Decision trees can be complicated and challenging to comprehend, particularly when working with a lot of data or numerous variables. This can make it challenging to pinpoint the crucial variables affecting a project's outcome. Another disadvantage is sensitivity to input data. Because decision trees are sensitive to changes in input data, various results may be obtained. It can be challenging to find precise and trustworthy data in the case of construction projects that are fraught with uncertainty (Maceika et al., 2021).

Another approach is Fuzzy logic. This method involves applying fuzzy set theory to the evaluation of investment projects. Fuzzy logic takes into account the imprecision and uncertainty associated with input data, allowing for more accurate and flexible analysis of investment projects. Study by Alhudaithi et al. (2018) demonstrate the effectiveness of fuzzy logic in managing various forms of uncertainty, such as technical and regulatory requirements.

However, the Fuzzy logic method has significant drawbacks. The first is limited applicability. Fuzzy logic works best when dealing with issues involving qualitative or hazy variables, like language or opinion. It might not be appropriate for assessing building projects that require accurate and objective data, such safety records or material requirements. The second is lack of transparency. It might be challenging to interpret and communicate fuzzy reasoning to stakeholders. This might be a difficulty for managing building projects because it might be challenging to explain the reasoning behind the model's choices (Habibi et al., 2018).

Therefore, modern methods explained above as well as traditional approaches cannot be applied for construction projects with extreme uncertainty due to significant drawbacks, so relevant methodology need to be applied.

Chapter 2. Methodology and results of evaluation the construction project

2.1 Main method

Methodology is introduced for construction project (residential real estate development) with extreme uncertainty. The aim of the project is to build and sell residential real estate. Extreme uncertainty comes from the fact that main project cash inflows are revenue obtained from selling residential real estate that depend on whether real estate will be sold or not in particular period of time. If real estate is sold, company will have earn revenue, if real estate is not sold to potential customer, company will earn nothing, that is extreme uncertainty.

Method discussed is not presented in well-known literature and not widely used in practice according to literature observed. Methodology is based on traditional NPV calculation, but unlike the traditional NPV method that can consider uncertainty only in terms of risks in discount rate calculation, proposed methodology accounts for extreme uncertainty that is incorporated by modelling exposure time (time to sale) of residential real estate (cottage) as a rare event followed by exponential distribution using Monte-Carlo Simulation approach.

The first step is to propose mathematical model NPV for construction project with extreme uncertainty. The next step is modelling exposure time. Then, implement Monte-Carlo Simulation modelling for calculation of NPV.

2.1.1 Mathematical model of NPV

Mathematical model for NPV is the following:

$$\mathrm{NPV} = -\mathrm{C}_0 + \sum_{i=1}^{6} \mathrm{NCF}_i \quad (1)$$

Where:

C_0 - the initial investments, it is amount of capital that is required to start the project. It is considered to be constant, and its estimate obtained from company.

NCF_i – net cash flow obtained from cottage i.

Net cash flow can be calculated according to the following general formula (this formula will be specified for construction project later):

$$\mathrm{NCF}_i = \frac{\mathrm{Price}_i - \mathrm{Tax}_i - \mathrm{Exp}_i}{(1+r)^{T_i}} \quad (2)$$

Where:

$Price_i$ - selling price of cottage i,

Tax_i - income tax on revenue from selling cottage i,

Exp_i – expenses related to cottage i, r - discount rate,

T_i - exposure time for cottage i. It is a time to sale for house i, calculated based on exponential distribution using random values change which leads to creating different Monte-Carlo Simulations. Parameter T_i (exposure time) characterizes extreme uncertainty and it is a random uncertain variable that depends on Price for cottage i.

2.1.2 Modelling exposure time

The next step is to determine model parameter – exposure time. Exposure time is modelling according to exponential distribution. Exponential distribution is a statistical distribution that models the time between two successive events (house sales) followed a Poisson distribution.

Poisson distribution describes a random discrete value X representing the number of events that occurred in a certain period of time, subject to a constant intensity of these events (λ).

Sales of houses follow a Poisson distribution because of the following features. They are not correlated with each other as it is supposed to that potential customers can make a sale deal after viewing advertisement, whereas the moments of viewing advertisement are independent. Probabilities of house sales are random, and the probability of each event does not change in time. Sales of houses happen relatively infrequently, and there is very little chance that a consumer will decide favorably as a result of viewing, so events are rare.

Probability to sell k house in a certain period of time can be calculated as:

$$P(X = k) = \frac{\lambda^k}{k!} e^{-\lambda} \quad (3)$$

$$X \sim P(\lambda)$$

Where:

λ – average number of houses sold in certain period of time (intensity),

e – exponent,

k – number of events.

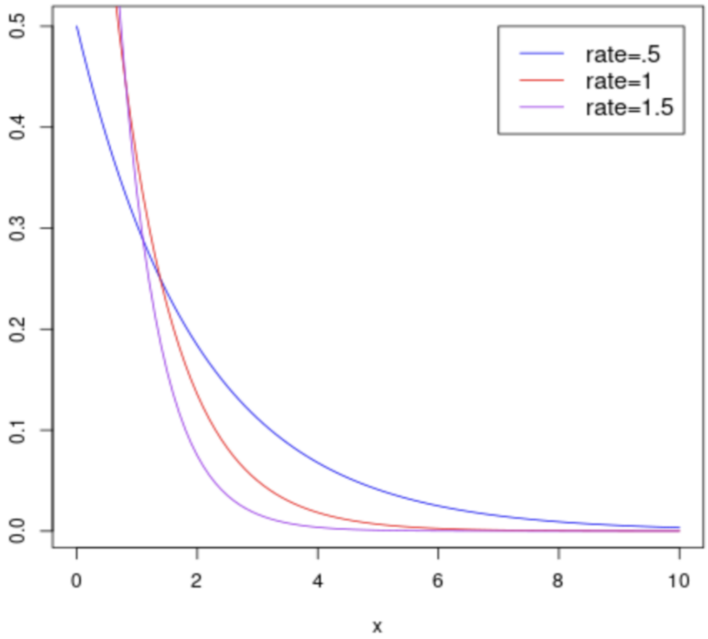
Exponential distribution has the same parameter λ as in Poisson distribution, but it should be $1/\lambda$. In this case parameter $1/\lambda$ shows average exposure time. Probability density function for random variable following an exponential distribution is:

$$f(x) = \begin{cases} \lambda e^{-\lambda x}, & x \geq 0, \\ o, & x < 0 \end{cases} \quad (4)$$

$$X \sim \mathrm{Exp}(\lambda)$$

The probability density function of a random variable X that follows an exponential distribution with various $1/\lambda$ parameters is depicted in the following graph:

Graph 1. Pprobability density function of exponential distributed variable.



Cumulative distribution function for random variable X following an exponential distribution:

$$F(x) = \begin{cases} 1 - e^{-\lambda x}, & x \geq 0, \\ o & , x < 0 \end{cases} \quad (5)$$

Let variable ζ is house exposure time and follows exponential distribution:

$$\zeta \sim \mathrm{Exp}(\lambda)$$

If F is a cumulative distribution function of a random variable ζ, then the random variable $F(\zeta)$ is uniformly distributed on [0,1]:

$$F(\zeta) \sim \mathrm{Unif} \in [0,1]$$

Let $F(\zeta)$ is equal to u:

$$F(\zeta) = u,$$

$$u \sim \mathrm{Unif}$$

Then in order to find variable ζ following exponential distribution one need to solve the following equation:

$$1 - e^{-\lambda \xi} = u$$

Where:

$$\xi = \frac{-\ln(1-u)}{\lambda} \quad (6)$$

So, in order to determine a random exposure time for each house, we must first solve the equation mentioned earlier and find a solution. The variable u is a random variable and its value changes randomly every time, ranging from 0 to 1 during each Monte-Carlo Simulation.

2.1.3 Modelling average exposure time

The next step is to access average exposure time ($1/\lambda$). Average exposure time is considered to be influenced by house price (that is input parameter and determined by the company): the higher house price, the longer exposure time and visa versa. This fact based on the following assumptions.

Firstly, if the price is much higher than the market value, then this can alienate potential buyers and they will look for alternatives, which will increase the sale time. In addition, the higher the price of a house, the more selective buyers can be who will look at it. This can result in the home being on the property market longer as the number of interested buyers can be significantly reduced.

Secondly, if the price is lower than the market value, then it can attract more customers who are looking for good deals. This can increase the demand for the house and lead to its quick sale. Furthermore, a low price may draw in buyers who are trying to purchase properties they can later resell for a profit.

Therefore, one need to model average exposure time based on house price. Let's assume that house price and its exposure time relates exponentially, as the best approximating function is exponent. For this reason, one need to collect primary expert estimates of exposure time and sales prices for particular objects of residential real estate for the last periods of time. It is important to consider similar residential real estate by the following characteristics: region, types of residential real estate, area, number of floors and others. Then based on these primary estimates build exponential regression model:

$$\lambda = a * e^{b*x} \quad (7)$$

Where:

a, b – coefficients,

x – house price.

2.1.4 Monte-Carlo Simulation

After model's parameters are determined, the next step is to implement Monte-Carlo approach. Monte-Carlo Simulation modelling is a statistical approximation method based on the simulation of random events; it is an algorithm that allows to perform numerical simulation using random number generation. The method is based on statistical methods, including the laws of probability and distribution of random variables. The main idea is to repeat the process using random model parameters. Each repetition represents one experiment, which is then used to generate statistical results. The more repetitions, the more accurate results can be obtained.

For this reason, for the variable exposure time T^i series of random values from 0 to 1 (following Uniform distribution) are generated. These random values are incorporated in modelling exposure time. Then Simulation modelling is launched, and the required number of experiments are performed (usually 1000 or 10000 experiments). As a result, series of different value of NPV are calculated. Final estimate of NPV is determined as mathematical expectation for all Monte-Carlo Simulations:

$$E(NPV) = \sum_{i=1}^{n} NPV_i \quad (8)$$

Where:

$E(NPV)$ – mathematical expectation of NPV, final value,

NPV_i – NPV that is calculated as a result of Simulation i.

Then confidence interval for this value is calculated as:

$$\overline{X} \pm t_{\propto/2} * SE \ (9)$$

Where:

$\overline{X}$ – is mean value,

$t_{\propto/2}$ - critical value from the Student's t-distribution table for the given level of significance and degrees of freedom,

SE – standard error, determined as standard deviation of the sample divided by number of elements in the sample.

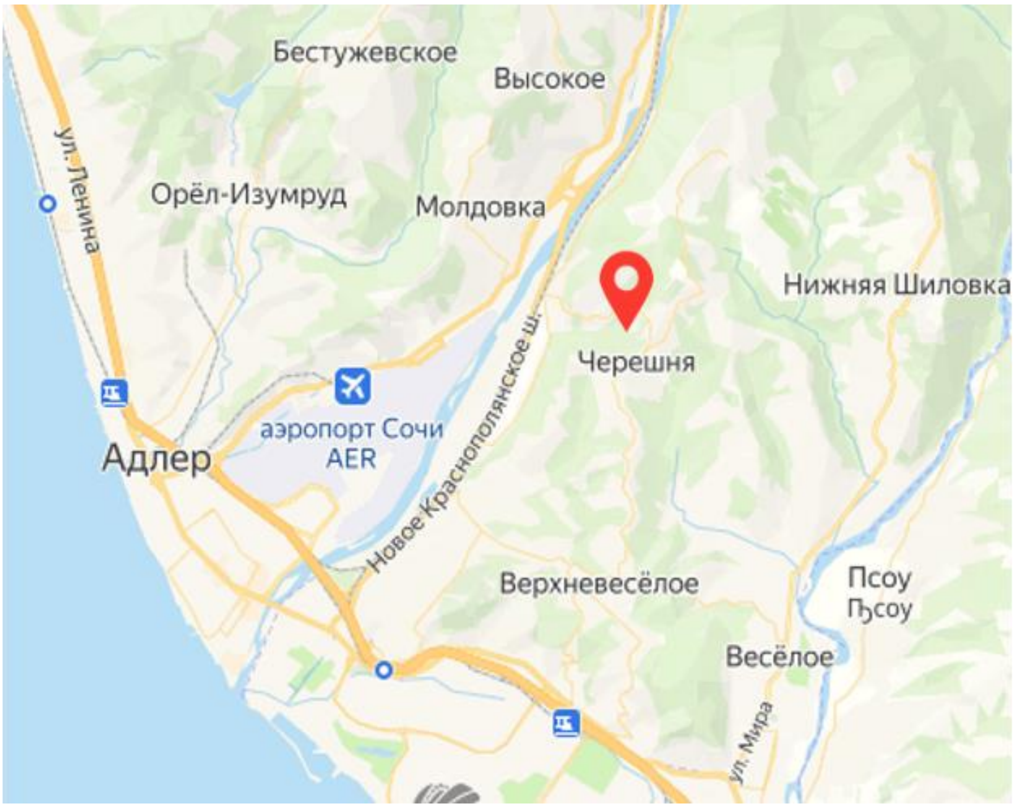
2.2 Description of project «NEO Sochi»

The proposed methodology will be implemented on real development project performed by Limited Liability Company "Center for project management in housing and utilities" – NEO Sochi. This project is realized under development project scheme, where LLC "Center for project management in housing and utilities" is developer, i.e. it performed this project by itself but with financing from Investor.

2.2.1 Project description

«Neo Sochi» - an elite cottage village of 6 cottages in the village «Chereshnya», Adler district, Sochi. The Chereshnya village is located in the Adler district of the city of Sochi. The eastern border of the village runs along the seashore, and the western - through the mountains of the Caucasus. The settlement is located at a distance of about 30 km from the Center of Sochi and a few kilometers south of the popular resort of Adler. Chereshnya village has convenient transport accessibility. One can get there by bus or car from the center of Sochi, or from Adler. The journey from the city center takes about 30 minutes, and from Adler - about 10-15 minutes. Travel time from the village of Chereshnya to the international airport of Sochi (Adler) usually takes about 30-40 minutes by car.

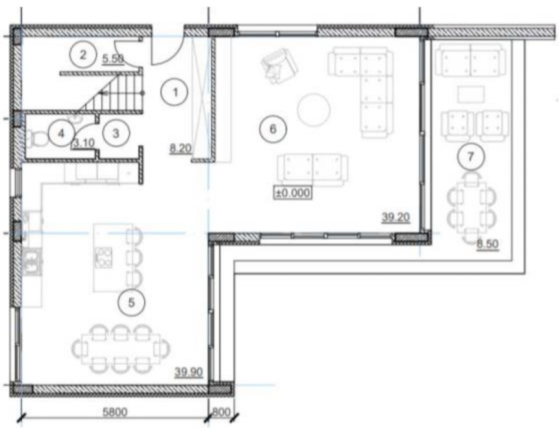
Scheme 1. Geographical position of NEO Sochi.



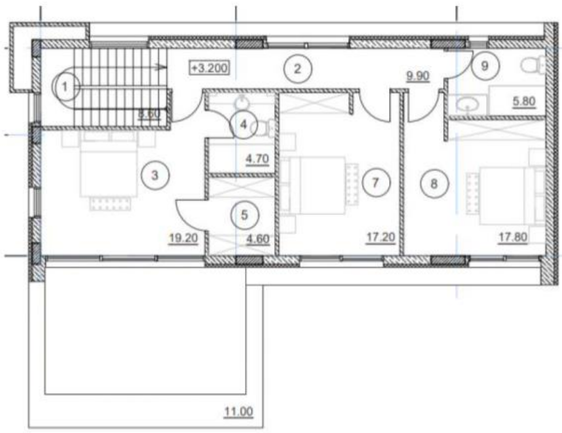
Source: Internet recourse (map)

On the territory of the village there are 6 cottages with an area of 215 m2 on plots of around 400 m2. Each cottage has two floors: on the ground floor there is an entrance hall, a bathroom, a kitchen-dining room, a living room, a terrace; on the second floor there are 3 bedrooms, a bathroom and a terrace. More detailed plan for grand and second floor are presented in the graphs below.

Scheme 2. Ground floor layout



Scheme 3. Second floor layout



Source: Company's reports.

NEO Sochi is a village situated in a picturesque natural setting. The village offers modern and stylish houses and cottages equipped with advanced technologies and premium materials. The cottages boast monolithic frame construction and are built using environmentally friendly materials with seismic resistance rated at 9 points. The white box finished houses come with smart home systems and connected communications that enhance their functionality.

The adjacent territory is level to the floor level of the house to create a seamless common space between the house and the terrace, and each house has private parking for 3-4 cars. Additionally, each villa has a spacious outdoor terrace enclosed for privacy, complete with a cozy hearth zone designed for warm evenings. Moreover, In case of demand from customers NEO Sochi can install a concrete pool that is 8 x 4.5 meters in size and up to 2 meters deep equipped with water supply systems, filtration, and decorative lighting.

NEO Sochi differentiates itself from other luxury villages through its active implementation of the Smart Home system. This technology includes neural networks, a smart "green" system with individual climate adjustment. Using a convenient mobile application for IOS and Android, homeowners can manually or automatically adjust the lighting, drive control, and security features throughout the home, based on sensor data and preconfigured scenarios. Motion sensors, temperature and humidity sensors, water leakage sensors, fire safety sensors, and wireless switches are all included, as well as voice assistant compatibility.

NEO Sochi is built according to an architectural design awarded by the Europe Property Awards Development in the Single Unit category and in the nominations "Best Architectural and Construction Solution" and "Energy Efficient House".

2.2.2 Input variables

The following extra information needed for implementation of introduced methodology was obtained from company’s management:

Table 1. Input variables.

№	Variable	Value
1	Initial investments	181 446 thousand RUB
2	Planned construction period	1,5 year (18 month)
3	Price for 1 cottage*	55 000 thousand RUB
4	Planned time to sale for 1 cottage	3 months
5	Income tax	6% from Revenue obtained from selling the cottages *
6	Security costs for 1 house per month **	15 thousand RUB

7	Housing and communal services housing and communal services per month**	5 thousand RUB
8	Other maintenance expenses **	1,5% a year from cottage's selling price
9	Bank commission***	1% from cottage's selling price
10	Realtor's fee***	5 000 thousand RUB

Source: Company's reports.

* Company applies simplified tax regime. Other taxes (except Income tax) was included into other maintenance expenses.

** These expenses are included into Maintenance costs.

*** These expenses are included into other expenses incurred at the time of the transaction.

2.3 Discount rate calculation

The method used to calculate the discount rate for a construction investment project is the cumulative construction approach, which considers the potential risks involved and relies on the opinions of experts. This approach has gained popularity among analysts and appraisers in the construction industry as it is well-suited for estimating the discount rate of a development project, owing to its ability to track changes in profitability over the entire implementation period. This method allows to take into account temporary factors and possible changes in market conditions via different risk premiums.

Another approach for discount rate calculation – CAPM has some disadvantages for development investment project. Firstly, CAPM does not consider the project's particular circumstances. The CAPM technique does not take into account the unique characteristics of the project because it is based on general statistics about market return and investment risk. Secondly, CAPM rely on risk evaluation. The CAPM approach relies on a risk assessment, which might be arbitrary and incorrect, to determine the discount rate. Also, the strategy does not account for how particular economic and financial elements may affect the project's risk. Thirdly, calculating the discount rate using the CAPM model demands proficiency and expertise from analysts. However, this model's application for determining the discount rate is often dismissed as national stock market indicators tend to approach it conservatively. Consequently, the calculated capital discount rate value is an average of all factors, failing to precisely reflect the risk level of a given project due to its location and the impact of local investment climate.

Calculation of discount rate using cumulative approach based on methodology proposed by Aswath Damodaran (Damodaran, 2012). According to this approach the risk-free rate of return is taken as the basis, for which the rate of return on federal bonds is most often taken, and then premiums for the risk of investing in the project are added to it, the amount of which is based on the contractor's own conclusion. Nominal discount rate can be defined by the following formula:

$$r_n = r_f + r_{pr\_ur} + r_{pr\_u} + r_{pr\_sr} \quad (10)$$

Where:

r_n – nominal discount rate

r_f – risk-free rate

r_{pr_ur} – premium for unsystematic risks

r_{pr_u} – premium for uniqueness of the object

r_{pr_sr} – premium for systemic risk

For the first parameter, risk-free rate r_f, it is necessary to take the rate of return of an alternative investment, which suits the following features:

1. Profitability has been determined and is known in advance.
2. Lowest possible chance that the money invested in this asset would be lost;
3. The maturity of this instrument roughly corresponds to the time investment length.

So r_f can be determined as returned of Russian governments bonds, deposit rate, key rate etc.

The main part in the cumulative construction method is risk premiums. In formula above there are 3 premiums: for unsystematic risks, uniqueness of the object and for systemic risks.

Premium for uniqueness of the object r_{pr_u} accounts for uniqueness of the property. It is determined according to the following scale:

Table 2. Premiums for uniqueness of the property.

Level of uniqueness	Premium for uniqueness of the object, %
Non-unique	0
Slightly different from the similar object	1
Unique object	2

Source: Author’s estimates.

Premium for unsystematic risks r_{pr_ur} is considered as additional risk associated with investing in the company. Premium for industry risk r_{pr_sr} is considered as additional risk associated with investing in the residential real estate industry. First of all, to calculate these premium the list of possible unsystematic risks that can significantly affect the company's activities are determined. Then each risk is assigned to certain level (low, below moderate, moderate, above moderate, high) and weight (1, 2, 3, 4, 5 correspondingly). 1 point for the lowest level of risk that has no strong influence on project, whereas 5 points for the highest risk with significant impact on project. Then all points are summed up and score weighted average WA is calculated:

$$WA = \frac{\sum_1^n (x_i * r_i)}{n} \quad (11)$$

Where:

x_i – number of risks with weight i,

r_i – weight of risk i (1…5),

n – number of risks.

Then calculated amount is converted into risk premium according to the scale (see table below), the formula is:

$$r_{pr\_ur} = x + (\frac{WA - y}{y - Y}) \quad (12)$$

Where:

x is left border of recommended risk premium according to the scale,

y is left border of WA according to the scale,

y-Y is range length of WA according to the scale (right border – left border).

Table 3. Scales for converted WA into premium.

WA	Premium, %
1 – 2,5	1 - 2
2,5 – 3,5	3 - 4
3,5 - 5	5 - 6

Source: Author's estimates.

Then final step is to calculate real discount rate according to the formula:

$$r_{real} = r_n - r_{inf} \quad (13)$$

Where r_{inf} is inflation rate.

For risk free rate r_f calculation Russian Government bonds with maturity 5 years was chosen:

$$r_f = 9{,}76\%$$

The list of unsystematic risks and corresponding level of risks that was accessed expertly is presented in the following table:

Table 4. Premium for unsystematic risks.

Risk	Level of risk, points				
	1	2	3	4	5
Unsystematic risks					
Cost overruns				✓	
Construction delays					✓
Permitting and regulatory issues	✓				
Changes in zoning laws or building codes		✓			
Ineffective management			✓		
Ineffective staff work				✓	
Competition from similar projects			✓		

Source: Author's calculations.

To calculate Premium for unsystematic risks WA was calculated and then r_{pr_ur} was obtained according to the scale:

$$WA = 3{,}14$$

$$r_{pr\_ur} = 3 + \left(\frac{WA - 2{,}5}{3{,}5 - 2{,}5}\right) = 3,64\%$$

The list of systematic risks and corresponding level of risks that was accessed expertly is presented in the following table:

Table 5. Premium for systematic risks.

Risk	Level of risk, points				
	1	2	3	4	5
Systematic risks					
Economic downturn				✓	
Changes in legislation			✓		
Increase in cost of imported materials					✓
Decrease in level of population's income				✓	
Increase in taxation			✓		
Ecology requrements		✓			
Changes in Consumer Behavior			✓		
The threat of terrorism			✓		
Continuation of the Special Military Operation					✓

Source: Author's calculations.

To calculate premium for systematic risks WA was calculated and then r_{pr_sr} was obtained according to the scale:

$$WA = 4{,}00$$

$$r_{pr\_sr} = 5 + (\frac{WA - 3,5}{5 - 3,5}) = 5,33\%$$

For the premium for uniqueness of the object r_{pr_u} the medium level was chosen because NEO Sochi is common cottages with no and not so unique compared to other cottages on the market except smart home system, which take some uniqueness differs from it traditional cottage settlements, so the resulting premium is:

$$r_{pr\_u} = 1\%$$

Resulting nominal discount rate (measured in percent per annum) is equal to:

$$r_n = 9{,}76\% + 3{,}64\% + 5{,}33\% + 1\% = 19{,}73\ \%$$

Then to calculate real discount rate we need to subtract inflation rate, that was chosen at 5% a year according to official forecast of Bank of Russia for 2023. Real discount rate (measured in percent per annum) is equal to:

$$r_{real} = 19{,}73\% - 5\% = 14{,}73\%$$

2.4 Evaluation of «NEO Sochi»

2.4.1 Regression model for average exposure time

To model average exposure time based on house price and build exponential regression model, one need to collect information about prices and exposure time for elite cottages in Adler district with similar features as NEO Sochi. This information was obtained from market reviews provided for LLC "Center for project management in housing and utilities" by real estate agency (name is hidden due to high confidentiality). These reviews have been provided by management LLC "Center for project management in housing and utilities" with high confidentiality. From these sources, prices and exposure time for 6 similar cottages was obtained. Cottages are similar in the following way: number of floors, square of land, square of cottages, location (all of them located in Chereshnya), age (up to 2 years after construction is finished), availability of additional amenities (swimming pool etc.) and other criteria.

Obtained primary estimates presented in the following table:

Table 6. Market primary estimates for real estate on Chereshnya (Sochi).

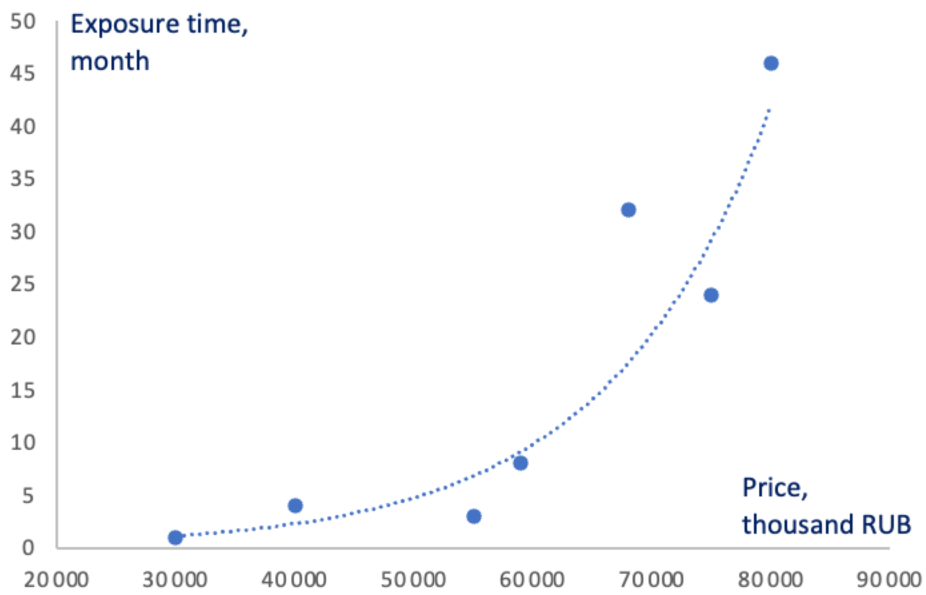
Price, thousand RUB	Exposure time, months
59 000	8
32 000	1
40 000	4
80 000	46
75 000	24
68 000	32

Source: Real estate agency's reports.

The following exponential regression model was built:

$$\lambda = 0{,}1256 * e^{0{,}00007*x} \quad (14)$$

Graph 2. Exposure time and price.



Source: Author's calculations.

2.4.2 Calculation of exposure time

Average exposure time is calculating according to formula (14). So, for determined price by the company, that is 55 000 thousand RUB, corresponding exposure time modelled by regression is 8,1 months. This amount reflects average exposure time predicted by model based on market data. But the company establish exposure time is 3 months, that is less than predicted by exponential regression model. The company establish such short exposure time, because NEO Sochi has smart home system, that quite new in the market and is not common in Chereshnya and plans that houses will be sold out quickly due to this fact.

Based on average exposure time 8,1 months the following random exposure time is generated in 1 Monte-Carlo Simulation:

Table 7. Random exposure time is for 1 Monte-Carlo Simulation.

	Cottages					
	1	2	3	4	5	6
Exposure time	8,2	1,4	2,2	2,3	4,4	8,4

Source: Author's calculations.

2.4.3 Evaluation of expected NPV

NPV for 1 Simulation is calculated according to the formula (1). NCF for cottage i is calculated according to the formula:

$$NCF_i = \frac{Price_i}{(1+r)^{t_0+T_i}} - \frac{(Tax_i+Exp\_tr_i)}{(1+r)^{t_0+T_i}} - \sum_{t=1}^{T_i} \frac{Exp\_m_i}{(1+r)^{t_0+t}} \quad (15)$$

Where:

Exp_tr_i – expenses incurred at the time of the transaction, including bank commission and realtor's fee

Exp_m_i – maintenance expenses for cottage i,

T_i - exposure time (time to sale) for cottage i,

t_0 - year when the construction of house is finished.

Maintenance expenses Exp_m_i is expenses incurred for house i by developer until house is sold. Before residential real estate is sold to the customer it remains on developer's balance sheet and company incurs the following maintenance cost:

- Utility expenses (electricity, gas, water, etc.)
- House maintenance expenses (cleaning the area, home security etc.)
- Other related expenses (expenses for property insurance, legal services, advertising activities, real estate sales fees, agency commissions, advertising and marketing costs, appraisals and preparation of documentation for the sale, all related taxes (except income tax), developer's fee (is included into other related expenses, cost structure is not disclosed due to confidentiality) etc.)

Year when construction of house will be finished t_0 is determined by the company.

Example of calculation CF of all expenses and revenue for cottage 1 with exposure time 8,2 month in 1 Monte-Carlo Simulation is presented in the following table:

Table 8. CF for cottage 1 with exposure time 8,2 month for 1 Simulation, thousand Rubble

Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Income:									
Revenue from selling cottage 1	0	0	0	0	0	0	0	0	55 000
Expenses:									
Maintenance costs	-89	-89	-89	-89	-89	-89	-89	-89	-19
Bank commission	0	0	0	0	0	0	0	0	-550
Realtor’s fee	0	0	0	0	0	0	0	0	-5 000
Income tax	0	0	0	0	0	0	0	0	-3 300
Net Cash Flow	**-89**	**-89**	**-89**	**-89**	**-89**	**-89**	**-89**	**-89**	**46 131**

Source: Author’s calculations.

Example of calculation PV of all expenses and revenue for cottage 1 with exposure time 8,2 month in 1 Monte-Carlo Simulation presented in the following table:

Table 9. PV of CF for cottage 1 with exposure time 8,2 month for 1 Simulation, thousand Rubble

Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Income:									
Revenue from selling cottage 1	0	0	0	0	0	0	0	0	39 947
Expenses:									
Maintenance costs	-70	-70	-69	-68	-67	-66	-65	-65	-15
Bank commission	0	0	0	0	0	0	0	0	-399
Realtor’s fee	0	0	0	0	0	0	0	0	-3 631
Income tax	0	0	0	0	0	0	0	0	-2 397
Discounted Net CF	**-70**	**-70**	**-69**	**-68**	**-67**	**-66**	**-65**	**-65**	**33 505**

Source: Author’s calculations.

Then similar calculations are performed for 5 other cottages. Example of calculation PV of NCF for all cottages in 1 Monte-Carlo Simulation presented in the following table:

Table 10. PV of NCF for all cottages for 1 Simulation, thousand Rubble

Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Discounted Net CF from:									
cottage 1	-70	-70	-69	-68	-67	-66	-65	-65	33 505
cottage 2	-70	36 391	0	0	0	0	0	0	0
cottage 3	-70	-70	36 052	0	0	0	0	0	0
cottage 4	-70	-70	36 001	0	0	0	0	0	0
cottage 5	-70	-70	-69	-68	35 082	0	0	0	0

cottage 6	-70	-70	-69	-68	-67	-66	-65	-65	33 409
Sum	**-420**	**36 041**	**71 846**	**-204**	**34 948**	**-132**	**-130**	**-130**	**66 914**

Source: Author’s calculations.

Resulting NPV for 1 Monte-Carlo Simulation calculating as:

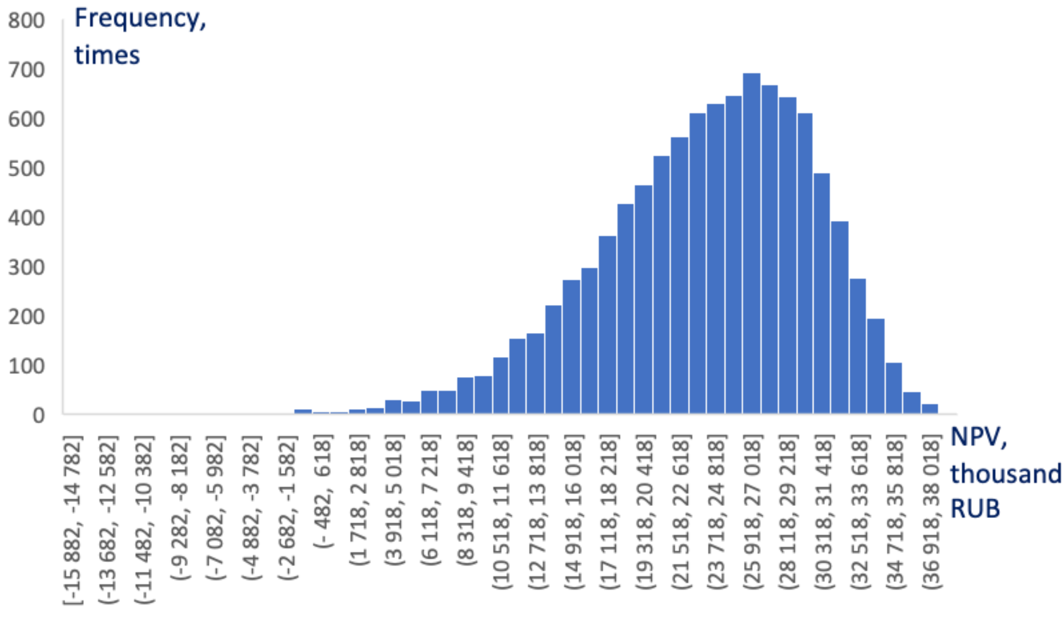
$$NPV_1 = -181\,446 + (-420 + 36\,041 + 71\,846 - 204 + 34\,948 - 132 - 130 - 130 + 66\,914) = 27\,267\ thousand\ Rubble$$

Then 10 000 Monte-Carlo Simulations of NPV are calculated and expected NPV is determined as:

$$E(NPV) = 23\,839\ thousand\ Rubble$$

Graphically all obtained Monte-Carlo Simulations are presented in the following chart:

Graph 3. Series of NPVs for all Monte-Carlo Simulations.



Source: Author’s calculations.

As can be seen from the graph, calculated expected NPVs are close to a normal distribution, median value is 24 492 thousand Rubble, standard deviation is 6 564 thousand Rubble.

Confidence interval is:

$$23\,008 < NPV < 24\,069$$

So, at the 95% significance level, the mean value of NPV is between 23 008 and 24 069 thousand Rubble.

Based on obtained Monte-Carlo Simulations probabilities for different values of NPV PD was calculated according to the following formula:

$$PD = \frac{\text{Number of Simulations with target value of NPV}}{\text{Total number of Monte-Carlo Simulations}} \qquad (16)$$

PD calculated for different value of NPV presented in the following table:

Table 11. Probabilities for different value of expected NPV.

Value of NPV, thousand Rub	Probability, %
NPV < 0	0,25%
NPV > 0	99,75%
10 0000 < NPV < 20 000	24,29%
20 0000 < NPV < 30 000	56,24%
30 0000 < NPV < 35 000	14,47%
NPV > 35 000	1,38%

Source: Author's calculations.

According to introduced methodology, project will be worthwhile and achieve positive NPV with high probability 99,75%, there is only little chance that project will not create additional value, as expected value of NPV will fall below zero with probability less than 1%. Moreover, with high probability more than 50% NPV will in range between 20 and 30 mln Rubble.

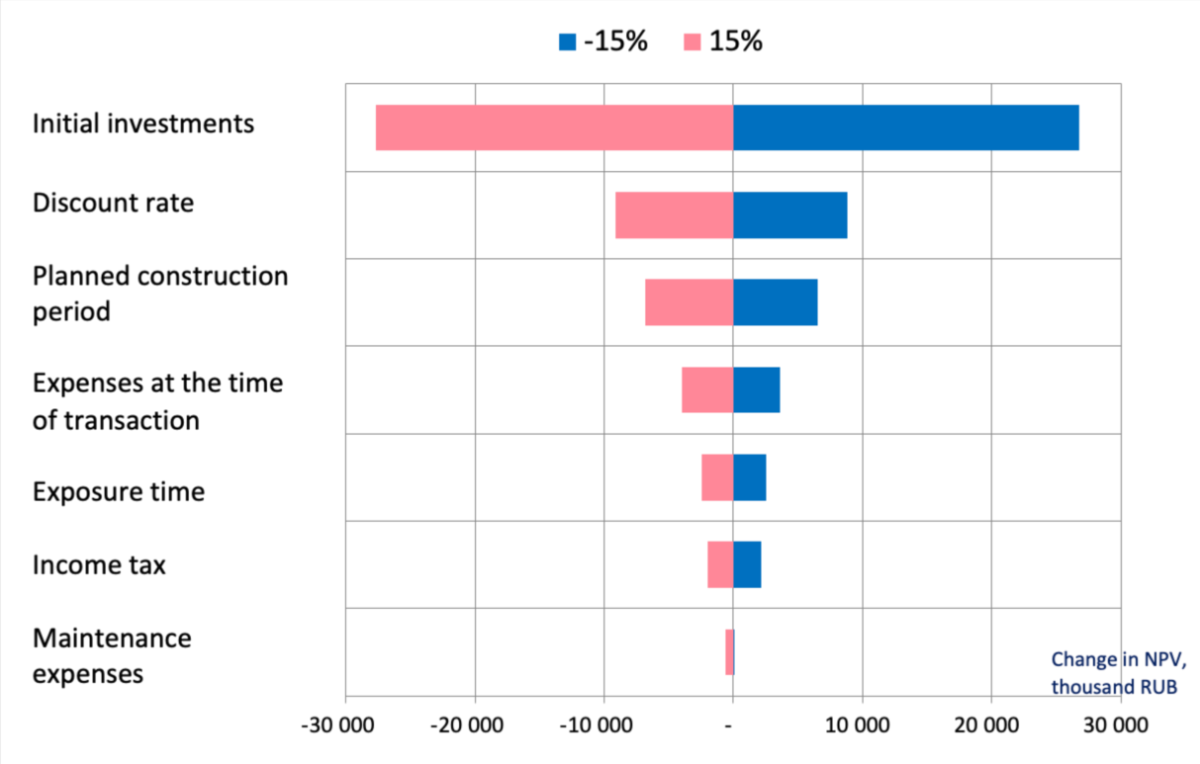
Then NPV using traditional NPV approach was calculated to compare with expected NPV obtained by introduced methodology:

$$Traditional\ NPV = 16\ 963\ thousand\ Rubble$$

2.4.4 Sensitivity analyses

Also, to better understand impact of model's parameters on expected NPV sensitive analyses was performed. This method consists in changing the selected parameters within certain limits (15%), provided that the other parameters remain unchanged. Sensitivity analysis gives opportunity to define the most critical variables that can most affect the effectiveness of construction project. For each variable's 15% changes (both positive and negative) value of expected NPV was calculated and then changes in NPV from base value (23 839 thousand Rubble) was defined. Variables are initial investments, discount rate, planned construction period, expenses at the time of transaction, exposure time, income tax, and maintenance expenses. Obtained results are presented in the following diagram:

Graph 4. Impact of 15% changes in parameters on NPV.



Source: Author's calculations.

Calculated NPV for 15% changes in parameters are presented in the flowing table:

Table 12. Expected NPV for 15% changes in parameters, thousand Rubble

Variable	$NPV_{+15\%}$	NPV_{base}	$NPV_{-15\%}$
Initial investments	-3 843	23 839	50 579
Discount rate	14 750	23 839	32 653
Planned construction period	16 989	23 839	30 378
Expenses at the time of transaction	19 863	23 839	27 463
Exposure time	21 703	23 839	26 195
Income tax	21 871	23 839	25 973
Maintenance expenses	23 259	23 839	23 897

Source: Author's calculations.

According to sensitivity analyses performed, initial investments have the strongest influence on expected NPV. Growth in initial investments by 15% leads to amount of 208 mln RUB investments that reduces expected NPV by 116%. On the contrary, 15% reduction leads to 154 mln RUB investments that increases expected NPV by 112%. Changes in discount rate, planned construction period and expenses incurred at the time of transaction have medium impact on expected NPV. 15% growth in these variables leads to 38%, 29% and 17% reduction in expected NPV correspondingly for discount rate, planned construction period and expenses incurred at the time of transaction. 15% reduction leads to 37%, 27% and 15% growth in expected NPV correspondingly. Changes in exposure time and income tax expenses have little impact on NPV. 15% growth in these variables leads to reduction in expected NPV by 8 %. On the contrary, 15% reduction in these variables leads to growth in expected NPV by 9%. Maintenance expenses has no significant impact on excepted NPV. Growth by 15% leads to reduction in expected NPV by only 2%, whereas 15% reduction leads increase in expected NPV by less than 1%. Tables with detailed results of sensitivity analyses are presented in Appendix.

2.5 Results and discussion

According to introduced methodology, on average NPV of construction project «Neo Sochi» is 23,8 million RUB, that is higher than NPV obtained using traditional approach. In terms of probabilities, the positive value of NPV will be achieved with high probability 99,75%. There is only little chance that project will fail and will not create any additional value, as negative value of NPV will be achieved with very small probability less than 1%. NPV in range between 10 and 20 million RUB will be achieved with probability approximately 24%. Moreover, with probability more than 50% NPV will be in range between 20 and 30 million RUB and with probability less than 15% NPV will be in range between 30 and 35 million RUB. NPV more than 35 million RUB is unlikely and will be achieved with probability less than 2%. If we compare results with traditional NPV method, expected NPV determined according to introduced methodology is higher than NPV obtained by traditional method (16,9 million RUB), so project seems to be more valuable. Project NEO Sochi is worthwhile using both methods.

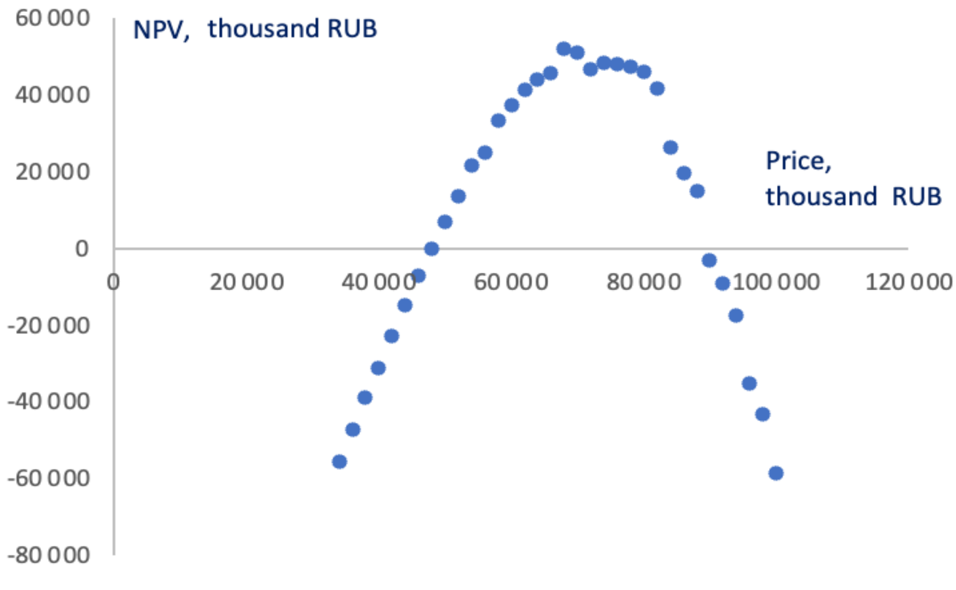
However, using traditional approach we get only 1 simple number that is difficult to interpret without extra information, in other words only one figure NPV say nothing to company's management about the project's efficiency. Moreover, traditional NPV relies on accurate estimates of future cash flows and does not consider uncertainty in CF, so number 16,9 million RUB is based on assumptions about future cash flow, such as fixed exposure time, price etc. If some parameters significantly change our NPV can become negative, and decision taken only by 1 NPV number can leads to failure for company. Moreover, in traditional NPV uncertainty is sometimes included into discount rate in terms of different risk premium, that is not correct and leads to wrong results – NPV become too small and not reflect true essence.

In contrast, unlike traditional NPV approach, presented methodology incorporates uncertainty in exposure time. Moreover, the discount rate used in calculation is business specific and not artificially increased by uncertainty as traditional NPV method sometimes does. Also, introduced method provides not only 1 figure, but range of possible values of NPV with determined probabilities. Thus, the result provided by presented methodology is more accurate, as it takes into account uncertainty in future cash flows and provides different figures NPV for 1 development project. Uncertainty is considered by modelling random exposure time that follows exponential distribution that depends on prices set by the company. Relation between prices and exposure time is built based on real market data, so every price is assigned to real exposure time observed in the market. Generating 10 000 different random exposure time with parameter determined by real market data, gives us set of different NPV defined randomly for one established price. Resulting NPV obtained by introduced methodology consider different scenarios of changing exposure time, i.e. incorporate uncertainty, and can be considered as more accurate with comparison with traditional NPV.

The first important property proposed method is that information obtained will be useful for managerial decision. So, obtained NPVs can be analyzed by company's management to take investment decisions and allows to define the likelihood of different project outcomes under uncertainty. It can also help to reduce the risks of investing in real estate projects, allowing to more accurately assess their potential profitability.

Another important property of proposed method is that obtained information can be used for determining optimal selling price for 1 cottage, that leads to maximum value of the NPV of the whole project, and price thresholds. This can help a business improve its financial performance and increase its efficiency. This price can be the starting point for developing a sales strategy. Determination of optimal price can be achieved by modelling NPVs for set of different prices, the relationship between rice and NPV is presented in the following graph:

Graph 5. Relationship between NPV and Price.



Source: Author's calculations.

2.6 Practical recommendations

New methodology for evaluation of construction development project with extreme uncertainty that has not been previously used by the company was developed. Introduced method allows company to get extra information for accessing the effectiveness of the development project and take investment decision based not on 1 figure.

Moreover, the approach for calculating discount rate especially for construction development project was proposed. The suggested method involved computing the discount rate through a cumulative construction approach that involved adding up the risk-free rate and various premiums based on unsystematic risks, systematic risks, and the distinctiveness of the property.

For NEO Sochi, optimal price that leads to maximum NPV of 48 million RUB is 74 million RUB. The prices lower or higher this value leads to decrease in NPV. Especially, according to the Graph 5 there are 2 price thresholds: 90 million RUB and 48 million RUB. For prices higher than 90 million RUB and lower than 48 million RUB, resulting NPV of development project is negative, so to achieve positive NPV company needs to establish price between 48 and 90 million RUB.

Important point here is that increase in prices leads to increase in NPV but until prices achieve some threshold after which NPV decreases. It can be explained as increase in prices leads to increase in exposure time. This results in increase in maintenance costs that is incurred until house is sold. These costs decrease project's cash flows, that leads to decrease in NPV.

As a result of the findings, the following practical suggestions were formulated for LLC "Center for project management in housing and utilities". The first is to set the optimal price of 74 million RUB for one cottage to get maximum expected profit from realizing construction project (NPV is 48 million RUB). The second is do not set prices higher than 90 million RUB and lower than 48 million RUB, as in these cases the project is not profitable as resulting profit from realization of project is negative and company earn nothing (resulting NPV of construction project is negative). The third is that to achieve positive profit (NPV is greater than 0) company needs to establish price for 1 cottage between 48 and 90 million RUB.

Conclusion

This work is devoted to evaluation of construction project «Neo Sochi» with extreme uncertainty. «Neo Sochi» - an elite cottage village of 6 cottages in the village «Chereshnya», Adler district, Sochi. Project is performed by LLC "Center for project management in housing and utilities", the aim of this project is build and sell 6 cottages. Extreme uncertainty comes from the fact that main project cash inflows are revenue obtained from selling residential real estate that depend on whether real estate will be sold or not in particular period of time. The complexity of such project lies in the fact that it contains many factors that can have a significant impact on the final result, but often cannot be predicted in advance. Traditional method NPV cannot be used for the evaluation of this construction project as it cannot truly account for extreme uncertainty. This is due to the fact that there is great uncertainty associated with changing market conditions and other factors that can significantly affect the amount of cash flows and project opportunities. This can lead to underestimation or overestimation of potential investments.

To evaluate project «NEO Sochi» special methodology was developed. Methodology based on one main source of uncertainty - exposure time. Prices and exposure time for similar cottages in the village «Chereshnya» were obtained as primary estimates from real estate agency at the request of the company. Based on this data exponential regression was built to quantify the relationship between prices and exposure time. Methodology assumes that prices are set by company realizing the investment project, and then based on given prices exposure time is modelled based on exponential regression model. After that, different exposure time is modelled based on random value. Then different Monte-Carlo simulations are calculated based on it, and final NPV is calculated as mathematical expectation. The Monte-Carlo method enables the assessment of a project even in situations of significant uncertainty, through the use of probability distributions to model project parameters. This results in both numerical and non-numerical metrics that can be relied upon for informed decision-making.

This methodology was successfully implemented, and goal of Master Thesis was achieved. The results of evaluation of project «NEO Sochi» are the following. Methodology indicates that on average NPV for the "Neo Sochi" construction project is 23.8 million RUB. The probability of achieving a positive NPV is high at 99.75%, and there is only a small chance of failure with a negative NPV of less than 1%. There is a greater than 50% chance of achieving NPV between 20 and 30 million RUB. NPV of over 35 million RUB is unlikely with a probability of less than 2%. Therefore, project «Neo Sochi» is worthwhile and with high probability will create value for investors and will be profitable. Expected NPV obtained by this method is slightly higher than figure obtained by traditional NPV. However, traditional approach provides a single number that is difficult to interpret without extra information and it doesn't account for uncertainty and can be difficult to interpret, while the presented methodology generates multiple NPV figures that incorporate uncertainty and are more accurate due to real market data. Moreover, NPV obtained through introduced methodology takes into account uncertainty in various exposure time scenarios, which makes it more accurate when compared to traditional NPV and provides range of NPV value with probabilities.

Results obtained in Master thesis have both practical and theoretical significance. As for theoretical significance, methodology developed in Master Thesis was described and implemented on real construction project with high uncertainty. According to literature review, methodology for construction projects with extreme uncertainty is not presented in well-known literature and not widely used in practice, so developed method has high theoretical significance and can be used for further research. As for practical significance, introduced method can be used for the evaluation of other construction development project, method accounted for extreme uncertainty and leads to more accurate results. Proposed method provides two important properties: first, the obtained information is useful for managerial decisions and can help analyze NPVs for investment decisions, reducing risks and assessing potential profitability. Second, the information can be used to determine optimal selling price for maximum NPV of the project and price thresholds, improving financial performance and efficiency. Moreover, based on this method, different practical recommendations can be developed.

Further research on the evaluation of construction projects with high uncertainty may focus on considering uncertainty in costs using Monte Carlo simulation method for calculating NPV. In the construction context, cost uncertainty can arise due to unforeseen problems, unexpected changes in plans, or other unexpected factors. The Monte Carlo simulation method allows to create models that can take into account such uncertainty. It will allow to conduct various experiments and analyze the results, which will determine the best course of action. In addition, more research can be done to address risks and uncertainties in other aspects of construction projects. For example, one might consider integrating risk and uncertainty into project schedules, cost estimates, and other cost-benefit measures.

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Appendix. Sensitivity analyses.

Sensitivity analyses: Initial investments

Changes in factor	Factor, thousand RUB		NPV, thousand RUB		% change in NPV
	before	after	before	after	
+15%	181 446	208 663	23 839	-3 843	-116,12%
-15%	181 446	154 229	23 839	50 579	112,17%

Sensitivity analyses: Discount rate

Changes in factor	Factor, thousand RUB		NPV, thousand RUB		% change in NPV
	before	after	before	after	
+15%	14,73%	16,94%	23 839	14 750	-38,12%
-15%	14,73%	12,52%	23 839	32 653	36,97%

Sensitivity analyses: Expenses at the time of transaction

Changes in factor	Factor, thousand RUB		NPV, thousand RUB		% change in NPV
	before	after	before	after	
+15%	5 550	6 383	23 839	19 863	-16,68%
-15%	5 550	4 718	23 839	27 463	15,20%

Sensitivity analyses: Maintenance expenses

Changes in factor	Factor, thousand RUB		NPV, thousand RUB		% change in NPV
	before	after	before	after	
+15%	2 018	2 321	23 839	23 259	-2,43%
-15%	2 018	1 715	23 839	23 897	0,24%

Sensitivity analyses: Income tax

Changes in factor	Factor, thousand RUB		NPV, thousand RUB		% change in NPV
	before	after	before	after	
+15%	14 543	16 724	23 839	21 871	-8,25%
-15%	14 543	12 362	23 839	25 973	8,95%

Sensitivity analyses: Planned construction period

Changes in factor	Factor, thousand RUB		NPV, thousand RUB		% change in NPV
	before	after	before	after	
+15%	18	21	23 839	16 989	-28,73%
-15%	18	15	23 839	30 378	27,43%

Sensitivity analyses: Exposure time

Changes in factor	Factor, thousand RUB		NPV, thousand RUB		% change in NPV
	before	after	before	after	
+15%	5,9	6,8	23 839	21 703	-8,96%
-15%	5,9	5,0	23 839	26 195	9,88%

Source: Author’s calculations.