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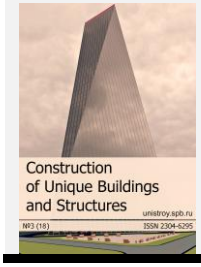

Construction
of Unique Buildings and Structures

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Comparative analysis of methods for estimating the project risks of unique buildings and structures

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ABSTRACT

The article is devoted to a comprehensive study of methods for risk assessment of investment and construction project. The absence of a universal method of evaluation determined the relevance of the work. The task was to explore the types of risks ICP and methods of evaluation, especially to explore methods of quantitative risk analysis. The object of the study was a construction of unique buildings and structures.

The main types of risks inherent in all investment projects and in particular the building have been identified. Special attention to the quantitative methods of risk assessment was given. Some of them were analyzed by the example in relation to investment and construction projects.

Selection of the normal distribution to describe the accidental changing of settings was justified in the article. It was concluded that the formation representative samples for study may be effected by the Monte Carlo method.

Contents

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1. Introduction

The objective trend of modern city planning is the construction of unique buildings and structures. This improves the appearance of the modern city, and this enables you to meet new challenges facing society and industry.

It is well known that the realization of the projects of construction of buildings and structures is characterized by a high degree of uncertainty. A large number of negative factors of different physical nature act on these projects. So, the risks are great enough to implement them.

2. Literature review

A quite number of researches are dedicated to the analysis of the theoretical premises of sources of risk in the investment industry, and on this basis to develop practical recommendations. Fundamental work [1] refers to them. Modern legislation of risk management is presented by international standards [2], [3]. The influence of various factors, evaluation methods and risk management are enough researched by foreign economists [4-9]. In work [10] proved a new classification of risks and explains the various ways of their evaluation. Various aspects of this topic in terms of the application are also discussed in detail in work [11]. The influence of various factors, methods of risk assessment and management are investigated and foreign authors [12], [13], [14], etc.

However, these studies did not consider specific risks of construction industry.

Risks of construction and installation works deeply and comprehensively described in the works [15], [16].

They are viewed through the prism of insurance activities. In addition, the characteristics of the construction of production unique buildings and structures are not considered. The problem of estimating the risk management of real estate in St. Petersburg in sufficient detail is disclosed in the work [17]. Identification of risks in investment and construction projects plays a major role in them, and therefore must be repeatedly during the construction period [17].

Unique buildings and structures (UBS) occupy a special place among the entire set of objects of capital construction. This is explained by a higher degree of risk and severity of accidents. So, they are subject to more stringent safety requirements [18]. This results to the necessity of more detailed study of project risks UBS. The multi-consideration of the issues presented, for example, in work [19]. However, the theory of the risks of design and construction these structures and buildings in general, is not yet sufficiently developed.

Individuality and complexity of each individual project of this type, as well as its application in the construction of the new technologies that do not waste on a large scale, greatly complicates the analysis of processes of manifestation risks. Therefore, the construction of unique buildings and structures related to one of the riskiest investment projects.

Components of risk in order to minimize its impact (or neutralization) at all stages of the investment and construction of the project (hereinafter COP) it is important to determine the correct and timely in a process of building production. Depending on what kind of impact the project's risks may have on the course of its realization depends on the correctness of the mechanism for the prevention of these risks. In such a manner, the insufficient development of methods for estimating the risk of investment and construction projects, determine the relevance of this work.

3. Problem definition

The purpose of this paper is to conduct a comparative analysis of existing methods for estimating the risk of investment and construction projects and the rationale for choosing the most effective among them for use for the construction of unique buildings and structures. To achieve this goal, following objectives are formulated here:

- to review the specifics of the unique construction buildings and structures;
- to analyze the types of risks and COP methods of assessment;
- to carry out the comparison of the methods of quantitative risk analysis.

4. Description of the research

The realization process of construction project of unique buildings and structures is the object of study in this article. Unique buildings and structures are individual class of design objects in urban planning [20]. These

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are the objects of capital construction, in project documentation which at least one of the following indicators is provided:

- height of over 100 meters;
- span more than 100 meters;
- availability of consoles more than 20 meters;
- embedment of the underground part (fully or partially) below the ground elevation of the planning more than 15 meters.

Unique buildings and structures also include entertainment, sports, religious buildings, exhibition halls, multi-office, shopping malls, etc. with a maximum estimated stay more than 1 000 people inside the facility or more than 10 000 people near the object [20].

According to the normative document [21] the term "investment-construction project" should be understood in two meanings:

- set of documents containing the formulation of objective of future activities and definition of a set of actions aimed at its achieving;
- set of required actions (work, services, management operations, acquisitions and decisions), aimed at achieving of stated objective, i.e. as documentation and as an activity.

In this article the term «investment-construction project» will be used in the second meaning. The risk for this type of project is a complex socio-economic concept [22]. Risk can be defined as the occurrence possibility of an adverse event in the design and construction operations of unique building or structure that entails various types of losses (loss of resources, revenue, etc.). Depending on the consequences, project risks can be divided into two groups which are technical and economic. Economic risks are defined as a measure of material loss when a risk of event appears [23]. Technical risks are caused by deficiencies of design, construction and installation works, irregularities in the operation, etc. The construction industry, like all industries of economics, is in the general system of strategic risks, such as social, political, economic, natural and industrial, scientific and technical. The main types of risks in construction projects are:

1. risk of increased interest rates;
2. risk due to the actions of competitors in this segment of the market;
3. the risk of non-viability of the project;
4. tax risk;
5. the risk of non-payment of debts;
6. the risk of non-completion of construction;
7. business risk;
8. the risk of failure to meet contractual obligations by the investor;
9. the risk of a wrongful act on the part of the owner;
10. the risk of non-realization.

The main causes (factors) of risks of investment-construction projects are:

- errors in the design estimate documentation;
- under qualification of experts, wares, technological processes or production;
- force majeure circumstances;
- delays in delivery;
- poor quality of raw materials, components, technological processes or production.

To conduct a comparative analysis of methods for estimating the project risks of the construction of a unique building (structure) it is required to determine the extent to which the methods allow to take into account these risk factors and consequences of their actions. Let us examine this question.

Risk assessment can be realized by two mutually complementary methods: qualitative and quantitative. The main task of qualitative analysis is forming a plurality of risk factors acting on the project, the identification of potential risks and their classification, and also evaluation of the significance of each of the considered factors. Currently, the most widely used methods of qualitative risk analysis are [24]:

- method of expert evaluation (Delphi method) is questionnaire of specialists with extensive experience in project activities;
- SWOT-analysis is method which involves identifying the factors of external and internal environment of the organization and dividing them into four categories: Strengths, Weaknesses, Opportunities and Threats [25];
- spiral ("rose") of risks is illustrated ranking of risks on the basis of qualitative assessments of risk factors;
- analog method is analysis of cumulative experience with analog-projects.

Map of project risks is a result of a qualitative analysis. On it in summary form the risks are presented at each stage of the project realization of a unique building (structure). The main disadvantage of using qualitative risk analysis is that its results do not provide information about possible casualties or their probabilities. However, the obtained resulting data provide the basis for quantitative analysis of risks.

Quantitative methods for risk assessment of investment-construction project of UBS allow obtaining numerical values of the risk levels of individual stages and of the project risk as a whole. A mathematical tool of quantitative methods of risk analysis is the theory of probability and mathematical statistics, theory of operations research, game theory, etc. The process of quantitative risk analysis includes the following steps:

- the creation of a mathematical model of the project risk;
- determination of the risk variables;
- determination of the probability distribution of selected variables and the definition of the range of possible values for each of them;
- determination of the existence or absence of correlations among the variables of risk;
- runs of the obtained models with different sets of input data to determine the level of influence of each variable on the negative outcome of the project;
- analysis of the results (the levels of risk).

Risk variables are the parameters of the mathematical model of risk, which are critical to the actual implementation of the project. For their identification is necessary to conduct a study on how their biases (even small) from the calculated values have a negative impact on the project. In this formulation of the problem for the selection of these variables sensitivity theory can be successfully applied [26, 27]. In the study the reactions of the project results to changes in design variables are measured with using the method of sensitivity analysis.

However, this method has significant disadvantage – when you use it you cannot take into account the occurrence probability of variable changes, i.e. the current uncertainty in the practice of design. How to get rid of this disadvantage.

Since for the project of a unique building (construction) it is not possible to select a representative sample for the construction of distribution graph with values of each of the risk variables, it should use their momentum characteristics: the expectation, variance, mean square (standard) deviation, and others [28]. To apply this approach to the project of a unique building (structure) it is proposed to use the normal distribution of the values of the variables in each of the phases of the project. This distribution is the limit in cases when the information about the object of study is severely limited. It was also found that many of the phenomena in the economy subject to the normal distribution law. Using modeling it must also use the assumption that the investigated factors are independent of each other. This is because the presence of correlated variables in the risk design assessment model leads to serious distortions of the analysis results.

Under the above assumptions it is very convenient to use Monte Carlo method in the simulation [29]. In this case, it is necessary to conduct a series of simulation tests for each of the factors, and to determine estimate of the desired risk parameter using shaped samples.

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Thus, a risk analysis is divided into two mutually complementary types: qualitative, which main task is to identify risk factors and circumstances that lead to risky situations, and quantitative, which allows to calculate the dimensions of certain risks and risk of the project as a whole by means of a mathematical model.

The expectation of a possible profit is calculated by the formula (1):

$$M = P_i \cdot c_i \quad (1)$$

P_i - the probability of risk; c_i - the value of estimated damage.

If the expectation is the same in both cases, the risk assessment is carried out on the dispersion.

The dispersion of the possible profit is calculated as follows:

$$D = \sum_{i=1}^{N} P_i \cdot (c_i - m_i)^2 \quad (2)$$

The standard deviation of possible profit (σ) is the square root of the variance:

$$\sigma = \sqrt{D} \quad (3)$$

Dividing the standard deviation of possible returns by the expectation of possible profit is the coefficient of variation of possible profit:

$$K_{вар} = \frac{\sigma}{m} \quad (4)$$

Intervals of monetary values are calculated using the formula (5):

$$[m - 3\sigma, m + 3\sigma] \quad (5)$$

According to the most common point of view, the measure of risk should be considered as the standard deviation (the positive square root of the variance).

The smaller the dispersion (variance) of the decision, project is the more advantageous, that is more predictable, with less risk.

If the variation (variance) is 0, then the risk is completely absent.

The example.

The task:

Two risky projects are offered to the stock company. On the first project with probability 0.2 receipts could reach 50 million rubles, with a probability of 0.6 this project will provide a profit of 60 million rubles, but with a probability of 0.2 that profit could reach 70 million rubles.

0.4 receipts will not be for the second project with probability. You can make a profit of 120 million with probability 0.2 income at $ 60 mln. rubles, and with probability 0.4.

Which project the shareholders should choose?

Solution:

Table 1. Input data on investment projects

Name of a source of profit	Number of the source of profit	Number of an investment project			
		Project 1		Project 2	
		Probability of the profit from the source	The possible amount of profit from the source	Probability of the profit from the source	The possible amount of profit from the source
source 1	1	0,2	50,0	0,4	0,0
source 2	2	0,6	60,0	0,2	60,0
source 3	3	0,2	70,0	0,4	120,0

Table 2. The calculated data on the project risks

	Number of an investment project	
Settlement indicators	**Project 1**	**Project 2**
The expectation of possible profit	60,00	60,00
The dispersion of possible profit	40,00	2880,00
The standard deviation of possible profit	6,32	53,67
The coefficient of variation of possible profit	0,105	0,894

Table 3. Evaluation of the boundaries the most possible project profit

	Number of an investment project	
Settlement indicators	**Project 1**	**Project 2**
The upper limit of the possible profit	41,026	-100,997
The lower limit of possible profit	78,974	220,997

More clearly the boundaries of possible profit can be seen in the Figure 2.

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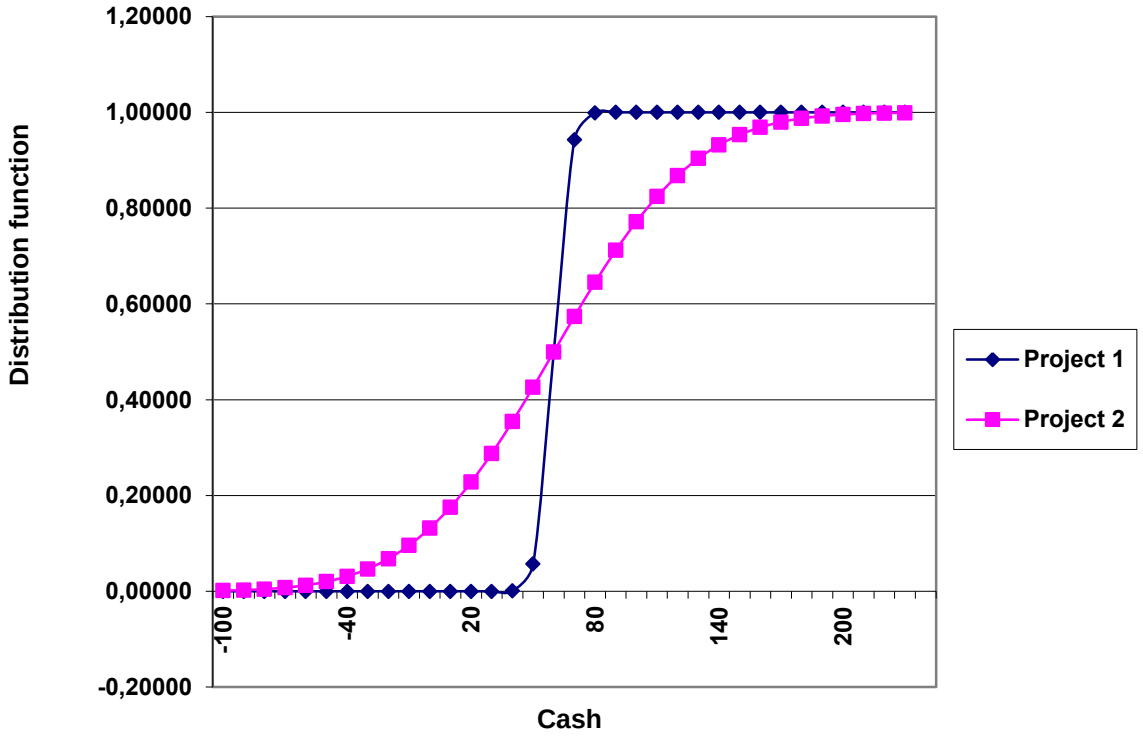

Figure 1. Distribution function of the magnitude of possible profit

Calculation example of possible profit shows that the second project is more risky than the first.

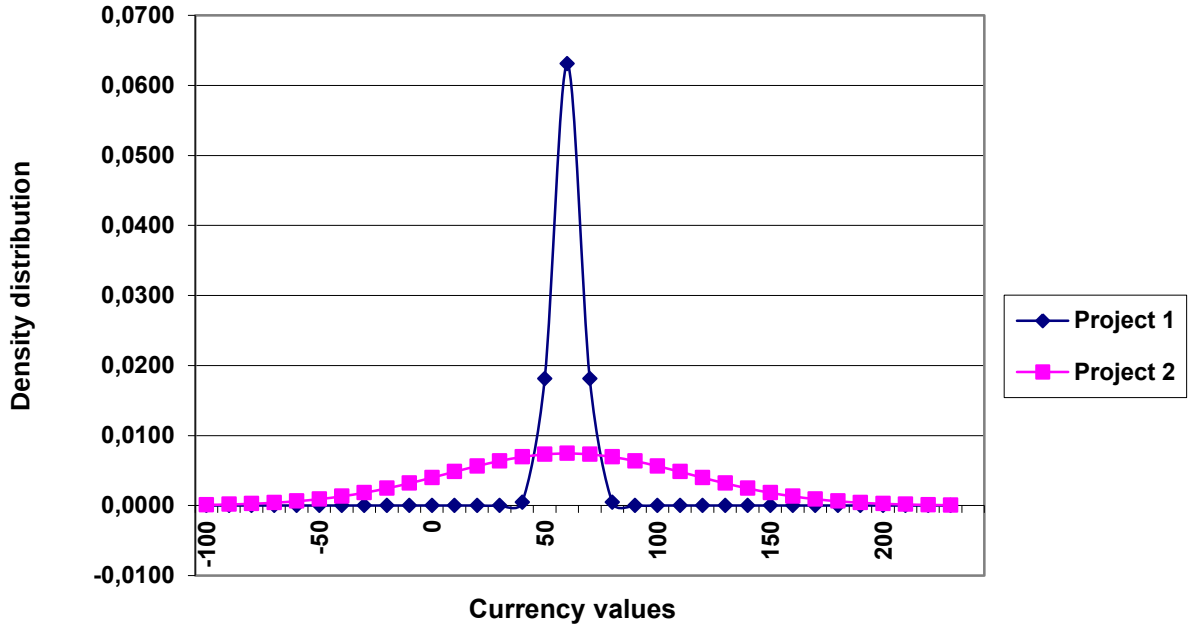

Figure 2. Probability distribution of possible profit

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5. Conclusions

Therefore, this article is justified advantage of the application of quantitative methods to evaluate the risks of the project unique buildings and structures. Selection of the normal distribution to describe the random variation of each of the parameters analyzed risk to the greatest extent corresponds to the peculiarities of the Russian market of construction products, characterized by subjectivity and dependence on non-economic factors and the high degree of uncertainty. Formation of representative (representative) samples for the study can be done under the assumptions made by the Monte Carlo method.

References

1. Shapkin A.S. *Economicheskie u finansovye riski. Ocenka, upravlenie, portfel' investicij*. [Economic and financial risks. Assessment, management, investment portfolio] *Moskva, Dashkov and Co.,* 2003. Pp. 6-8. (rus)
2. Risk Management Standards. Federation of European Risk Management Assotiations (FERMA).
3. BS 6079-3:2000 «Project management Part 3: Guide to the management of business related project risk».
4. Yingbin Feng. Effect of safety investments on safety performance of building projects. Safety Science. 2013. № 59. Pp. 28–45.
5. Savvakis C. Savvides. Risk Analysis in Investment Appraisal // Project Appraisal. 2004. №9. Pp. 3-18.
6. Brighouse D., Hontoir J. Financial Markets and Risk // Global Professional Publishing. 2008. 342 p.
7. Pandremmenou H., Sirakoulis K., Blanas N. Success factors in the management of investment projects: a case study in the region of Thessaly // Procedia - Social and Behavioral Sciences. 2013. №74. Pp. 438-447.
8. Bredin K., Söderlund J. Project managers and career models: An exploratory comparative study. // International journal of project management. 2013. № 31. Pp. 889-902.
9. Gil N., Tether B. S. Project risk management and design flexibility: Analysing a case and conditions of complementarity // Research Policy. 2011. № 40. Pp. 415-428.
10. Valdaitsev S.V. *Ocenka biznesa. 3 izdanie* [Business Valuation. 3 edition], *Prospekt*. 2008. Pp. 57-58. (rus)
11. Ptuhina I.S., Vyatkin M.E., Musorina T. A. Aspects of cost engineering, its role and influence on implementation of investment project // Construction of Unique Buildings and Structures. 2013. №9 (14). Pp. 46-56. (rus)
12. Shenkir Th.B., Shenkir W., Walker P.W. Risk management. Practice leading companies. Williams. 2008. 208 p.
13. Brigham Y., Ehrhardt M. *Finansovyj menedzhment. 10 izdanie* [Financial Management. 10 edition], SPb., 2009. Pp. 586-591. (rus)
14. Gapenski L. *Finansovyj menedzhment* [Financial Management] SPb., 1997. Pp.11-16. (rus)
15. Ryzhkin I.I. *Riski stroitel'stva i montazha* [Risks of construction and installation]. *Izdatel'stvo: Ankil*, 2006. Pp. 64-67. (rus)
16. Ryzhkin I.I. *Strahovanie stroitel'stva. Inzhenernye aspekty* [Construction. Engineering aspects]. *Izdatel'stvo: Ankil*, 2006. Pp. 114-118. (rus)
17. Tarasova I.V. Revealing of risks the investment and construction projects in system risk of management // Modern Problems of Science and Education. 2012. № 4. 2001. 3 p. (rus)
18. GOST R 54257-2010 *Nadezhnost' stroitel'nyh konstrukcij i osnovanij. Osnovnye polozhenija*. [Reliability of structures and grounds. Key provisions] (rus)
19. Soldatenko V.S. *Matematicheskoe modelirovanie. Upravlenie riskami proektov unikal'nyh zdanij i sooruzhenij.* [Mathematical modeling. Risk management projects unique buildings and structures.] St.Petersburg. Polytechnical University edition, 2012. Pp. 38-66. (rus)
20. Town Planning Code of the Russian Federation. 29.12.2004 N 190-FZ.
21. Kossov V.L., Shahnazarov A.G. *Metodicheskie rekomendacii po ocenke jeffektivnosti investicionnyh proektov (vtoroe izdanie).* [Guidelines for evaluating the effectiveness of the investment project] Moscow. *Eckonomija*, 2000. 15 p.

22. Zavadskas E.K., Turskis Z., Tamosaitiene J. Risk assessment of construction projects // Journal of civil engineering and management. №1 (16). Pp. 33-46.
23. Ptuhina I.S., Liskov A. A., Ptuhin I.A. Development of total cost management in construction // Construction of Unique Buildings and Structures. 2012. №5. Pp.17-20. (rus)
24. Gracheva M.V., Sekerin A. *Risk-menedzhment investicionnogo proekta* [Risk Management Project] Unity-Dana, 2009. Pp. 8-15. (rus)
25. Maysak O.S. SWOT analysis: the difficulty of searching for links between factors // Caspian Journal: Management and High Technologies, 2013. № 1. 152 p. (rus)
26. Tomovich P., M. Vukobratovic. Kniga po teorii chuvstvitel'nosti. Izdatel'stvo: Sovetskoe radio, 1972, s.10, 44.
27. Jovanovic P. Application of sensitivity analysis in investment project evaluation under uncertainty and risk. International journal of project management. 1999. № 4(17). Pp. 217-222.
28. Вензель Е. С. Теория вероятностей. М. Наука, 1969. С. 139-146. (rus)
29. Емельянов А.А., Власов Е.А., Дума Р. В. Имитационное моделирование экономических процессов. М., Финансы и статистика. 2002, С. 17-23. (rus)
30. Peters Edgar E. Chaos and order in the capital markets. A New View of Cycles, Princes, and Market Volatility. INC. New York, John Wiley & Song, 2000. 288 p.
31. Hans Thamhain. Curbing Risks in Complicated Projects // Project Management Journal. 2013. № 2. Pp.1-2.
32. Tonchia S. Industrial Project Management: Planning, Design, and Construction. Emereo Pty Ltd. 2008. Pp.3-27.

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Сравнительный анализ методов оценивания рисков проектов уникальных зданий и сооружений

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ИНФОРМАЦИЯ О СТАТЬЕ	**История**	**Ключевые слова**
УДК 69.003.12	Подана в редакцию 24 октября 2013 Оформлена 31 марта 2014 Согласована 31 марта 2014	инвестиционно-строительный проект; уникальные здания; риски; метод оценки; количественный анализ рисков; вероятностное распределение; метод Монте-Карло;

АННОТАЦИЯ

Статья посвящена комплексному исследованию методов оценки рисков инвестиционно-строительного проекта. Отсутствие универсального метода их оценки определило актуальность работы. Была поставлена задача изучить виды рисков ИСП и методы их оценки, в особенности исследовать методы количественного анализа рисков. Объектом исследования являлось строительство уникальных зданий и сооружений. Определены основные виды рисков, свойственных всем инвестиционным проектам и строительным в частности. Особое внимание уделено количественным методам оценки рисков. Некоторые из них на примере были разобраны применительно к инвестиционно-строительным проектам. В статье обоснован выбор нормального распределения для описания случайного изменения параметров. Сделан вывод, что формирование представительных выборок для исследования может быть осуществлено с помощью метода Монте-Карло. +7 (911) 954 5688; soldatenko-tn@bk.ru (Tamara Nikolajevna Soldatenko, Senior lecturer)

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Литература

1. Шапкин А. С. Экономические и финансовые риски. Оценка, управление, портфель инвестиций. М., Дашков и Со. 2003. С. 6-8.
2. Risk Management Standards. Federation of European Risk Management Assotiations (FERMA).
3. BS 6079-3:2000 «Project management Part 3: Guide to the management of business related project risk».
4. Yingbin Feng. Effect of safety investments on safety performance of building projects. Safety Science. 2013. № 59. Pp. 28–45.
5. Savvakis C. Savvides. Risk Analysis in Investment Appraisal // Project Appraisal. 2004. №9. Pp. 3-18.
6. Brighouse D., Hontoir J. Financial Markets and Risk // Global Professional Publishing. 2008. 342 p.
7. Pandremmenou H., Sirakoulis K., Blanas N. Success factors in the management of investment projects: a case study in the region of Thessaly // Procedia - Social and Behavioral Sciences. 2013. №74. Pp. 438-447.
8. Bredin K., Söderlund J. Project managers and career models: An exploratory comparative study. // International journal of project management. 2013. № 31. Pp. 889-902.
9. Gil N., Tether B. S. Project risk management and design flexibility: Analysing a case and conditions of complementarity // Research Policy. 2011. № 40. Pp. 415-428.
10. Валдайцев С. В. Оценка бизнеса. 3 издание, М., Проспект. 2008. С. 57-58.
11. Птухина И.С., Вяткин М.Е., Мусорина Т.А. Аспекты стоимостного инжиниринга, их роль и влияние на реализацию инвестиционного проекта // Строительство уникальных зданий и сооружений. 2013. №9 (14). С. 46-56.
12. Shenkir Th.B., Shenkir W., Walker P.W. Risk management. Practice leading companies. Williams. 2008. 208 p.
13. Бригам Ю., Эрхардт М. Финансовый менеджмент. 10 издание. Санкт-Петербург. 2009. С. 586-591.
14. Гапенски Л. Финансовый менеджмент. Санкт-Петербург, Школа экономики. 1997. С.11-16.
15. Рыжкин И.И. Риски строительства и монтажа. Изд-во Анкил, 2006. С. 64-67.
16. Рыжкин И.И. Становление строительства. Инженерные аспекты. Изд-во Анкил, 2006. С. 114-118.
17. Тарасова И.В. Выявление рисков инвестиционно-строительных проектов в системе риск-менеджмента // Современные проблемы науки и образования. 2012. № 4. 2001. 3 с.
18. ГОСТ Р 54257-2010 Надежность строительных конструкций и оснований. Основные положения.
19. Солдатенко Т.Н. Математическое моделирование. Управление рисками проектов уникальных зданий и сооружений. СПб., Изд-во Политехнического ун-та, 2012. С. 38-66.
20. Town Planning Code of the Russian Federation. 29.12.2004 N 190-FZ.
21. Коссов В.Л., Шахназаров А.Г. Рекомендации по оценке эффективности инвестиционно-строительных проектов (2 издание). М., Экономика, 2000. 15 с.
22. Zavadskas E.K., Turskis Z., Tamosaitiene J. Risk assessment of construction projects // Journal of civil engineering and management. №1(16). Pp. 33-46.
23. Птухина И. С., Лисков А. А., Птухин И.А. Развитие стоимостного инжиниринга в строительстве // Строительство уникальных зданий и сооружений. 2012. №5. С.17-20.
24. Грачева М.В., Секерин А. Риск-менеджмент инвестиционного проекта. Юнити-Дана, 2009. С. 8-15.
25. Майсак О.С. SWOT-анализ: объект, факторы, стратегии. Проблема поиска связи между факторами // Каспийский журнал: менеджмент и высокие технологии, 2013. № 1. 152 с.
26. Tomovich P., M. Vukobratovic. Kniga po teorii chuvstvitel'nosti. Izdatel'stvo: Sovetskoe radio, 1972, s.10, 44.
27. Jovanovic P. Application of sensitivity analysis in investment project evaluation under uncertainty and risk. International journal of project management. 1999. № 4(17). Pp. 217-222.
28. Вензель Е. С. Теория вероятностей. М. Наука, 1969. С. 139-146.
29. Емельянов А.А., Власов Е.А., Дума Р. В. Имитационное моделирование экономических процессов. М., Финансы и статистика. 2002, С. 17-23.
30. Peters Edgar E. Chaos and order in the capital markets. A New View of Cycles, Princes, and Market Volatility. INC. New York, John Wiley & Song, 2000. 288 p.
31. Hans Thamhain. Curbing Risks in Complicated Projects // Project Management Journal. 2013. № 2. Pp.1-2.
32. Tonchia S. Industrial Project Management: Planning, Design, and Construction. Emereo Pty Ltd. 2008. Pp.3-27.

Солдатенко Т.Н, Быкова Ю. В., Дзьоник Е. М., Фидрикова А. С. Сравнительный анализ методов оценивания рисков проектов уникальных зданий и сооружений. /
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