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ANALYSIS OF FINANCIAL RISKS AND DIVERSIFICATION PORTFOLIO OF INVESTMENT AND CONSTRUCTION PROJECT

Statement of the problem. The article investigates the financial risks and the development of a deterministic model of their dependence on the implementation of the investment and construction of the project, taking into account the influence of external and internal factors, as well as an opportunity to diversify the portfolio of investment and construction project.

Results. In the light of studies of existing capital asset pricing models, deterministic model dependence of the level of financial risk of investment and construction of the project was identified taking into account the influence of factors. The resulting dependence of the standard deviation of the portfolio of its level of diversification to determine the possibility of administrative influence on the level of total risk during the construction phase.

Conclusions. The proposed deterministic model dependence of the level of financial risk of investment and construction of the project and describing the investment portfolio performance will most effectively carry out calculations to determine the degree of risk as in separate projects and the portfolio as a whole, which will allow a more rational organization of work in the field of finance and investment and construction activities.

Keywords: financial risk, diversification, portfolio investment and construction project.

Introduction

An investment construction project as a business engagement that is impacted by a number of financial risks will be run in cooperation by a contractor and construction firms. In this case a financial risk is a risk incurred by the contractors and construction firms associated with possible critical consequences hindering timely contract payments. Therefore if industrial and financial activities undertaken by a particular individual do not involve loans, there are only business risks associated with a particular activity they specialize in that they run. Once there are loans involved in investment funding such as bank loans, shared sponsorship, mortgages, etc., the developer runs extra risks of losing some of their property (or all if he faces bankruptcy) which should a loan-paying capacity is declining will cover long-term and short-term debts of a commercial organization (a bank).

1. Study of factor models in theory and practice of investment analysis. Studies of the dependence of a result index (efficiency) on business risks have been a major concern for scientists domestically and abroad. One of the most common factor models in theory and practice of investment analysis is capital asset pricing model (CAPM) introduced by W. Sharpe and J. Lintner in the mid 1960s.

Quantitative assessment of a factor of increasing efficiency depending on the financial risk impact is largely overlooked. The following assumption is what the study is based on: due to the price of loan funds already including investment risk compensation, efficiency premium associated with financial risks, not only a difference between actual weighted average cost of capital (WACC) and the same index computed using risk-free efficiency ($WACCr_f$). The above assumption is mathematically represented by the following expression:

$$FR = WACC - WACCr_f = \frac{k_e \times CК + r \times ЗК}{CК + ЗК} - \frac{k_e \times CК + r_f \times ЗК}{CК + ЗК} = \left(r - r_f\right) \times \frac{ЗК}{CК + ЗК}, \quad (1)$$

where k_e is the price of the equity, coefficient; *СК* is the equity, thousand roubles; *r* is the weighted average interest rate (actual or planned) on loan funds, coefficient; *ЗК* is loan funds, thousand roubles; (r-r_f) is financial risk premium for 100 % capital lending (due to bank loans, corporate bonds, third-party loans, etc.), coefficient; *ЗК*/(*СК* + *ЗК*) is a percentage of loan funds in the overall investment project, coefficient.

The resulting expression *FR* indicates a critical dependence between a financial risk level and loan funds in the overall amount invested into an investment construction project capital expenditure. This is in total agreement with the previous definition of financial risk as being subject to change. For the developer and construction firms is an *extra* risk occurring if loan funds are involved.

2. Dependence of the investment profit on business and financial risks. Based on the CAPM and the above method of computing financial risk levels (*FR*), the formulas of the dependence of the investment profit, business and financial risks for different types of funding a project and β-coefficient (Table 1).

Table 1

Dependence of the investment profit on business and financial risks

β-coefficient	Specific weight of loan funds in the overall invested capital $d_{ЗК}$, coefficient		
	$d_{ЗК} = 0$	$d_{ЗК} = 0.5$	$d_{ЗК} = 1.0$
β = 0.5	$r_i = \frac{r_m + r_f}{2}$	$r_i = \frac{r_m + r}{2}$	$r_i = \frac{r_m - r_f}{2} + r$
β = 1.0	$r_i = r_m$	$r_i = \frac{2 \times r_m - r_f + r}{2}$	$r_i = r_m - r_f + r$
β = 1.5	$r_i = \frac{3 \times r_m - r_f}{2}$	$r_i = \frac{3 \times r_m - 2 \times r_f + r}{2}$	$r_i = \frac{3 \times (r_m - r_f)}{2} + r$

The analysis of financial risks will be completed only if there is a factor analysis of possible change of the general index over a future period. This makes it necessary to adhere to the principles underlying the system analysis concept. A system approach enables the analysis of *FR* not only as another index but also present it as a result index which can be affected by less significant factors. In order to address this, it is important that more significant factors affecting *FR*.

3. Designing a deterministic model of the dependence of financial risks of an investment construction project considering external and internal factors. A comprehensive study of possible causes of lower financial risks needs the following five factors to be identified (Table 2): *long-term investment attractiveness into a real economy sector* (lines 1-2); *real profit of an investment project* (lines 3-4); *investor's profit* (lines 5-6); *levels of financial delays in debt payments* (line 7); *structure of the invested capital* (line 8).

Each of these factors has a relevant analytical index. In order to correctly identify the major directions of management to achieve a more significant reduction in financial risk levels *FR*, financial analysts need to determine how much each of the factors influences it. This can be addressed only provided there is a relevant factor model of dependence in place.

Table 2

Characteristics of the factors affecting financial risks of an investment construction project

Factors represented by analytical indices	Methods of computing the index
1. Investment attractiveness index	Difference between the internal rate of return and risk-free return rate *(IRR)* and risk-free return rate
* The index describes the attractiveness index of some risky investments in real economy sector compared to fairly safe investments in particular financial assets. A significant increase in the return rate in a certain market sector compared to financial investments makes it more attractive for new investors. Increasing competition decreases economic profit, which makes it less likely yo achieve a performance level of industrial and financial activities to pay long-term and short-term debts. There are increasing financial risks.	
2. Index reversely proportional to the coefficient of attractiveness of long-term investments	Ratio of risk-free retrun rate to the internal return rate of an investment project
* An increase in this index is interpreted as contributing to lower attractiveness levels of investment construction projects associated with industrial production. Poor competition makes it more likely for a contractor to reach a certain return rate (not negative return). This index is reversely proportional to financial risks. However, when this index is over one, there is no commercial interest to this type of capital investment: it is safer and more profitable to invest in risk-free financial assets than to invest in risky projects.	
3. Real internal return rate of an investment construction project	Difference between the projected *IRR* and annual inflation rate
*The impact of inflation undermines investment. The larger the resulting real return rate (not considering inflation), the more chance the contractor has to timely pay their debts. An increase in this index reduces financial risks. A negative impact of the index indicates there are losses incurred and absolutely no chance of paying the debts using the revenue generated by a project (a critical situation)	
4. Coefficient of real return rate of an investment construction project (not considering inflation)	Ratio of the internal return rate of an investment construction project to the annual inflation rate

End of Table

Factors represented by analytical indices	Methods of computing the index
*The coefficient is interpreted similarly to the previous one. If the real return rate is less than 1, investment return rate will pay a negative impact of inflation and a debt will be paid due to the previously invested capital (resulting in a reduction in pure circulation capital or more adversely, in a sale of out of circulation assets). The resulting index (level of *FR)* and factor property are inversely proportionate. It should be remembered that the internal return rate is a minimum return level and real return rate of a project is greater than *IRR*, the contractor undertaking an investment construction project has a potential of cutting down financial risks.	
5. Real return rate of the investor (lender, creditor)	Difference between the interest rate and annual inflation rate
*Depending on the financial capacity of the contractor undertaking an investment project, their credit history, reputation, business connections, risks involved in a certain investment and probability of achieving financial outcomes through implementing it as well as the lender's policy regarding investment lending, this index can vary considerably. The less it is, the fewer financial risks are involved.	
6. Index reversely proportionate to the investor's real return rate	Ratio of the annual inflation rate to the interest rate of borrowed capital
*This index is never over one as the price of borrowed capital always includes the expected inflation rate. However, the more it approaches one, the less the lender's real return rate is, the less financial support debts they are to pay get and fewer financial risks are involved respectively.	
7. Average interest rate of borrowed funds	Weighted average interest rate of different borrowed funds
*An increase in the interest rate increases financial expenditure associated with paying borrowed funds rates for higher return rates. Financial risks are on the increase. A reduction in *FR* is possible due to cheaper borrowed funds.	
8. Percentage of the borrowed funds in the overall investment construction project	Ratio of the borrowed funds to the total borrowed and owned funds invested in a project
*As borrowed funds emerge in the capital structure, there is a chance of a debt not being paid off. There can be no *FR* only if 100% of a project is funded by owned capital. The factor analysis makes the following allowance: financial risks are inversely proportionate to the percentage of the borrowed funds in the overall invested capital.	

Note. *The comments on change in financial risks affected by a relevant factor

As a massive of statistic and record information about investment construction enterprises of Voronezh was being expanded as well as the results were applied in practices of Russian companies participating in investment projects, the author developed a deterministic model of the dependence of financial risks on different external and internal factors:

$$FR = r \times \frac{ЗК}{ЗК + СК} \times \left(1 - \frac{r_f}{IRR} \times \frac{IRR}{i} \times \frac{i}{r}\right) = r \times d_{ЗК} \times \left(1 - k_1 \times k_2 \times k_3\right). \quad (2)$$

There are certain flaws in the study. This means it is necessary that organization mechanisms of perspective evaluation of the indices are developed based on which a factor analysis of financial risks will be performed. The use of the analysis methods and resulting factor models of the dependence in accounting assists more robust financial and investment plans prioritizing the enterprise owners' and lenders' interests.

4. Modelling a contractor's investment portfolio depending on its diversity. It is suggested that risks involved in individual projects and combinations of capital investments are analyzed in a study of financial risks at the construction stage. Potentially lower return rates are characterized by the overall, diversity and system (market) risks. The dependence between these indices as shown in Fig. 1 illustrates management effects on the overall risks using a combination of assets in a diversified investment portfolio.

In order to reduce the overall risks, financial managers will merely need a diversified investment portfolio to make it possible for its unsystematic component to drop. As for financial investment, in order to significantly reduce diversified risks, there should be a portfolio including 4—6 properties (land, public buildings — kindergartens, schools, urban infrastructure, maintenance and redevelopment of housing and industrial premises, private housing) of different randomly selected companies in place.

As for diversification of long-term (capital) investments depending on risks of individual projects, their industrial specification, price and structure of the capital, a level of DR can be considerably reduced using a combination of 2—5 capital investment options. Investment portfolio including two assets (projects) are most indicative of the dependence of diversified risk and expected return rate. Two critical situations are proposed for review. Let us assume in the first case there are two equally risky projects *A* and *B which, if combined, will cause the deviation of an investment portfolio to be zero.* Change in financial cash flow of both investments as affected by the identical conditions are in Fig. 2 and 3.

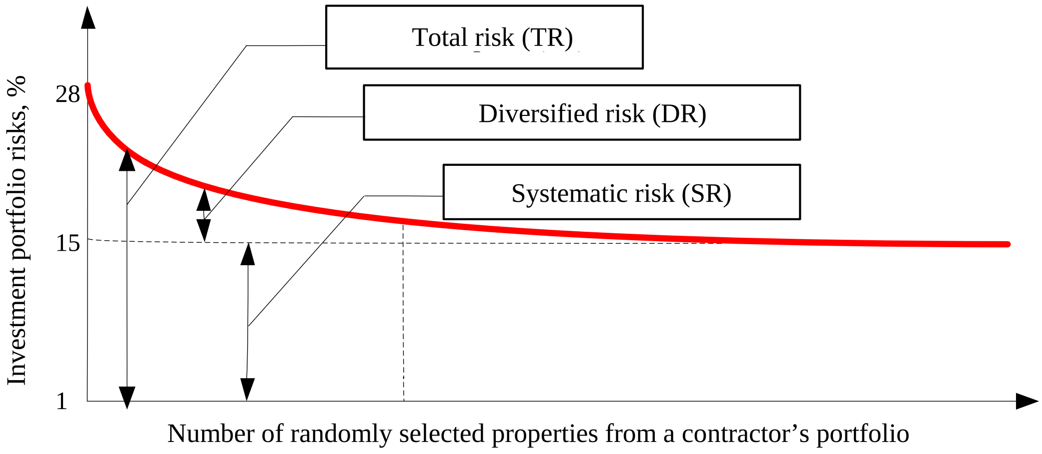
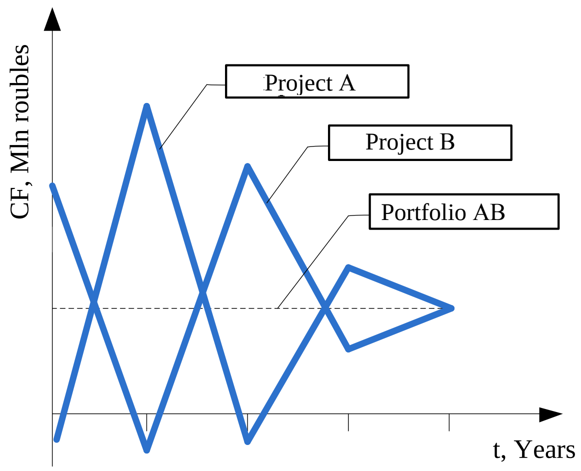
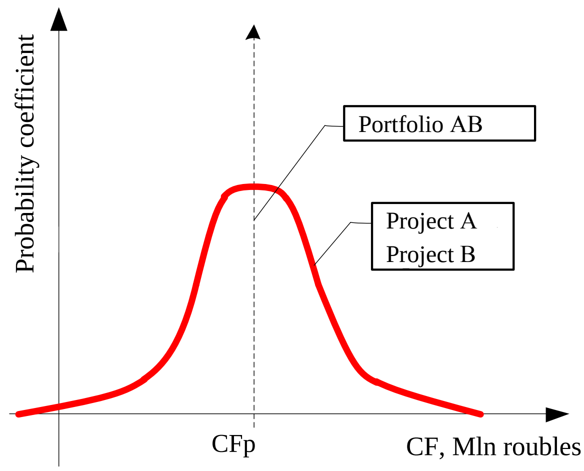


Fig. 1. Dependence of a standard deviation in investment portfolio (risk) on its diversification





CFp — planned financial cash flow

Fig. 2. Oscillations of financial cash flow

Fig. 3. Probabilistic distribution of financial cash flow

The main cause of combining investment construction projects with relatively high risk levels into an investment portfolio is that financial cash flow (return rate or other expected outcomes) affected by certain macro- and microeconomic factors will change reversely. This being the case, a reduction in the return rate of an investment option will be compensated for by growing return rates of the other. Commonly, we are dealing with *projects with different industrial specification aiming at differentiated manufacturers and consumers not equally dependent on the government’s economic policy* regarding economy regulation, current situation at the world’s commodity and finance markets.

The second situation is characterized by an investment portfolio including projects C and D. This being the case, financial cash flows affected by the identical risk factors will change (increase or decrease) in absolute synchrony as time passes. Therefore, the above investment (capital) portfolio will be as risky as some of its individual components. This is visually presented in Fig. 4 and 5.

Fig. 5 shows that a standard deviation of the portfolio *CD* will be completely consistent with the index computed individually for projects C and *D*. This essentially means that this portfolio is not diversified in terms of reducing unsystematic risks.

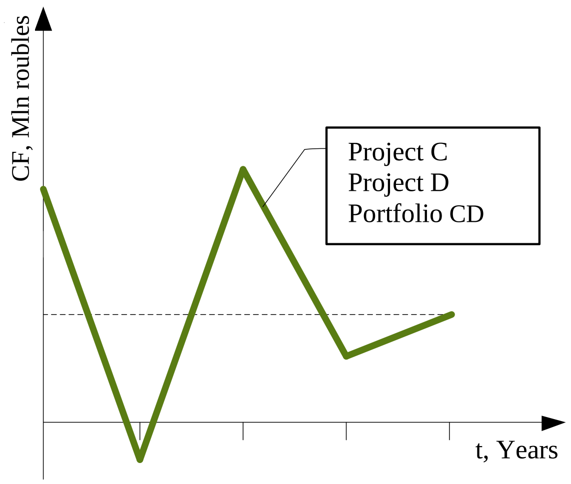


Fig. 4. Oscillation of financial cash flows

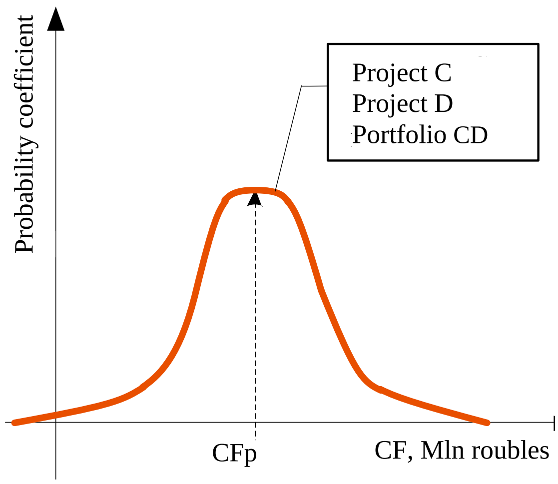


Fig. 5. Probabilistic distribution of financial cash flow

The mutual dependence of investment assets (bonds, projects, etc.) is determined by how they are affected by different risk factors, i.e. the correlation can be said to be described as a tendency of a few variables to change in conjunction. In order to measure mutual changes in the projects, a correlation coefficient *r* is used. It ranges from –1.0 to +1.0.

The value of *r*, which is +1.0, shows that change in the return rate of the projects is simultaneous (Fig. 4 and 5), while *r*, which is –1,0 indicates an opposite change in the evaluated variables (Fig. 2 and 3). Finally, the zero correlation coefficient indicates that the projects are not related in any possible way, i.e. change of the return rate of one of them does not depend on change of the identical index of the other investment option.

In fact, a combination of two randomly selected projects will have the correlation coefficient from +0.5 to +0.7. In this case analysists can reduce the impact of *DR*, while completely cutting off the negative impacts of specific uncertain factors on an investment program in this combination of projects is not possible.

Similarly as in the situation with an individual investment option, diversified risk can be characterized by a standard deviation. The original standard deviation of the portfolio can be given by the formula

$$\sigma_p = \sqrt[p]{\sum_{i=1}^{n} \left(r_{pi} - r'_p\right)^2 \times P_i}, \quad (3)$$

where r_{pi} is the return rate of a portfolio in the *i*-th situation; $r_p{'}$ is the expected return rate of an investment portfolio; P_i is a probability in the *i*-th situation.

The use of only σ_p in investment analysis is unlikely to help management decision-making. An essential addition to the evaluation of an optimal investment combination is the analysis of covariance and correlation coefficient.

Covariance is an index characterizing the connection of the return rates of assets included in an investment portfolio. If the projects *A* and *B* are combined, covariance of this portfolio ($CO\ V_{AB}$) is given by the formula:

$$COV_{AB} = \sum_{i=1}^{n} \left(r_{Ai} - r'_A\right) \times \left(r_{Bi} - r'_B\right) \times P_i, \quad (4)$$

where r_{Ai} $r_{B\mathrm{i}}$ are the return rates of the projects *A* and *B* in the *i*-th situation; $r_{A,}$ r_B are the expected return rates of the projects *A and B*.

Hence, if the projects *A* and *B* are equally affected by the same risk factor, the expressions in the brackets will be both positive and negative in each certain situation. It therefore means that the product of the brackets is always positive. Meanwhile if the return rates of the projects change reversely, the product of the brackets is negative. When the outcomes of undertaking projects do not change consistently (inconsistently), the product of the brackets can be both positive and negative and the sum of the products will approach zero.

Covariance will have a positive effect if all the projects included in the portfolio change consistently and each investment option has high risk levels; covariance will have a massive negative effect if each project is highly uncertain and oscillations in its return rates will be opposite to changes in the return rates of the remaining projects included in the portfolio; covariance will approach zero if the return rate of the projects does not change consistently or these investments have low risk levels.

Unfortunately, the index *COV* cannot be an objective criterion for comparing alternative investment portfolios. The correlation coefficient r_{AB} is recommended for that.

It is given by the formula

$$r_{AB} = \frac{COV_{AB}}{\sigma_A \times \sigma_B}. \quad (5)$$

Knowing the structure of an investment portfolio, we can present a standard deviation in the combination of the projects *A* and *B* as follows:

$$\sigma_p = \sqrt{d^2 \times \sigma_A^2 + (1-d)^2 \times \sigma_B^2 + 2 \times d \times (1-d) \times r_{AB} \times \sigma_A \times \sigma_B}, \quad (6)$$

where *d is the percentage of the project A* in an investment portfolio; (1 - *d) is the percentage of the project B.*

In practice, it might be essential to identify risk levels of an investment portfolio including more than two assets. In this case the index is given by the formula

$$\sigma_p = \sqrt{\sum_{i=1}^{n}\sum_{j=1}^{n} d_i \times d_j \times COV_{ij}}. \quad (7)$$

Conclusions. *Therefore, the analysis of financial risks for construction investment produced the following conclusions:*

— the most commonly used in science domestically and abroad are factor models for the theory and practice of investment analysis;

— the formulas of the dependence of the return rate, business and financial risks for different funding options of projects and β-coefficient were identified;

— based on statistic and record information of investment construction enterprises of Voronezh as well as the practical application of the results in Russian companies participating in their own investment programs, a deterministic model of the dependence of financial risks involved in an investment construction project on different external and internal factors was proposed;

— in order to reduce the total risks, there is a model of a diversified investment portfolio using the example of different critical situations;

— the formulas for identifying diversified risks of an investment portfolio were set forth.

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