SIMULATION ANALYSIS OF THE INVESTMENT ACTIVITY EFFECTIVENESS OF THE DEVELOPMENT BANK

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ABSTRACT
The paper examines the investment activity of the Development Bank of Kazakhstan. On the basis of the study, we propose an imitation system for analyzing the efficiency of the bank's investment activity and an algorithm of its functioning. The stages of the preliminary examination of the investment projects are considered. The criteria for selecting investment projects are proposed which apply even under the conditions of uncertainty caused by incomplete or inaccurate information on parameters and conditions of project implementation. The extension method is applied to optimize the investment parameters.

KEY WORDS
Development Bank of Kazakhstan, investment portfolio, business project, integral indicators of the project, uncertainty, optimization, simulation analysis, parameter “disturbances”, expansion method.

1. Introduction
One of the most important aspects of economic activity of any development organization is investment planning. At present, the problem of choosing the optimal balanced portfolio becomes particularly relevant in connection with the expansion of the investment activity of the banking sector and the development of the economy as a whole. One of the important tasks of the investment activity of the banks of Kazakhstan, including the Development Bank, is the selection of the most promising investment projects for funding. The expansion of the investment activity of banks in Kazakhstan, including the Development Bank, is constrained due to a number of reasons common at the initial phase of development of banking strategies like the historically small practical experience in the field of investment activity. The issues of investment activity including that for banks were analyzed in multiple research studies considering the theoretical aspects of the investment project choice, taking into account various indicators. These studies focus primarily on common approaches to the investment portfolio choice using the theoretical framework developed by Tobin, Markowitz and others. Given somewhat narrow focus on the portfolio choice, these studies sidestep many stages of investment bank's lending policy formulation process, necessitated by the intricate dynamics of investment banking. This omission raises practical implementation issues for determining the investment policy of a bank. The provision of liquidity, security and return on investment requires taking into account the dynamic processes in modeling investment. In this work we continue developing an integrated approach to the investment analysis and decision-making process based on computer simulations. Our simulation method can handle analytically intractable distributions for parameters and stochastic disturbances arising in banking operations. We also propose a new method for optimizing the allocation of funds, given different priorities and risks, while taking in account not only general volatility but also the "disturbances" affecting the parameters of the model.

2. Methodology
2.1 The structure of the simulation system for analyzing the efficiency of investment activities of the Development Bank of Kazakhstan
The high-level structure of the simulation system and efficiency analysis of the bank investment activity (see Figure 1) must include the following basic steps (Shukaev et al, 2015):
1. Preliminary examination of projects;
2. Bank appraisal of projects;
3. Investment performance analysis;
We formulate the following multi-stage algorithm for the operation of the investment analysis system.
Stage 1. Preliminary review of the projects. Step 1. Search and attraction of potential borrowers (applicants). Step 2. Check the applicant's documentation packages for completeness and consistency. Questionnaire based verification of the applicant’s background based on such criteria as credit history and involvement into money laundering activities. In case if the applicant fails to meet any of the basic eligibility requirements, or has
unsatisfactory risk profile, the Bank rejects the applicant (Annual account of The Development Bank of Kazakhstan for 2014).

Stage 2. Appraisal of projects.
Step 1. The assessment of financial indicators of the applicant:
   a) liquidity ratios (current ratio, intermediate ratio, quick ratio, absolute (strict) ratio);
   b) solvency ratios (financial stability ratio, debt ratio, long-term debt ratio, long-term debt coverage ratio);
   c) turnover ratios (asset turnover ratio, equity turnover ratio, inventory turnover ratio, receivables turnover ratio, length of the average credit cycle period);
   d) profitability ratios (return on sales, return on assets, return on equity)
Step 2. Shortlisting promising projects based on financial indicators.

Stage 3. Investment performance analysis.
Step 1. Calculation of integral indicators of the project (Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Payback Period (PP), Return of investment (ROI), Social Return on Investment (SROI)).
Step 2. Selection of investment projects depending on the conditions of implementation, taking in account the uncertainty.

Stage 4. Optimization of investment parameters.
Step 1. Optimizing the investment portfolio.
Step 2. Depending on the choice of the modeling method (analytical or simulation based) for the randomly distributed parameters, choose one of the following steps:
   a) analytical characterization of the range of variable parameters; or
   b) modeling the variable parameters and determining the range of changes in non-stationary parameters of the model, that lead to an improvement in the optimal solution of the problem.

Let us consider stages 3 and 4 in more detail.

2.2 Investment performance analysis

There are several methods for assessing the attractiveness of the investment project that use different indicators to select a project. Each technique is based on an important basic principle: the project realization should profit the investor. In practice, various financial indicators characterize the project from different perspectives in accordance with the interests of the stakeholders associated with the investment.

The mathematical formulas used for calculation of the first five indicators (NPV, IRR, PI, PP, ROI) are
described in detail in the research papers (Smolyak, 2008; Грачев, 2007; Biegel, 1971). Calculation of project’s social return on investment (SROI) is somewhat trickier since it is a qualitative assessment, the value of which lies in the range from 0 to 1. The most significant social investment projects should have a value of SROI close to one. The determination of this parameter should take into account possible outcomes of the project, such as: sales revenue, environmental and social results, financial results (taxes, amortization, profit), etc.

There are three ways to determine the values of SROI:

- To use Churchman-Ackoff method;
- To simulate possible SROI values modeled as realizations of a multi-dimensional random variable with known distribution laws of its input components (social and environmental results, financial results, revenues from sales of products, etc.);
- To build a forecast function as in (Зайченко, 2003).

After calculating all integral indicators for selecting investment projects one can use classic methods of voting (Pareto, Condorcet, Borda) (Smolyak, 2008; Грачев, 2007). Since the number of selected projects is not always predetermined, the authors of the article suggest to use the Borda count method. The algorithm for selecting investment projects on the basis of the Borda count method is given in (Biegel, 1971).

In case of project selection under conditions of uncertainty caused by incompleteness or inaccuracy of information on the conditions for their implementation (for example, the uncertainty regarding the level of inflation), one can use the well-known criteria of decision-making, such as the Laplace criterion, the Wald criterion, the Hurwitz criterion and the Savage criterion (Зайченко, 2003). The detailed description of the selection algorithms of one or more projects under uncertainty conditions is given in (Shukayev and Yergaliyeva, 2015).

2.3 Simulation and optimization of investment parameters

Let’s consider the problem of optimal funds allocation. The amount S of funds is to be allocated among enterprises from K economic sectors in order to stimulate innovative development projects (Тихонов, 1965).

Formally, the objective of the Bank can be stated as follows:

- minimize the expected variance of the future payoffs
  \[
  \min \text{var} \left[ \sum_{k=1}^{K} \sum_{i=1}^{n^k} \left( x_i^k \sum_{t=0}^{T} \beta_t^i \gamma_{it}^k \right) \right] \tag{1}
  \]
  subject to a target required expected net present value (NPV)
  \[
  E_0 \left[ \sum_{k=1}^{K} \sum_{i=1}^{n^k} \left( x_i^k \sum_{t=0}^{T} \beta_t^i \gamma_{it}^k \right) \right] \geq B \tag{2}
  \]

- and diversification restrictions
  \[
  \sum_{i=1}^{n^k} x_i^k \leq A_k S, \quad k = 1, K \tag{3}
  \]
  \[
  \sum_{k=1}^{K} \sum_{i=1}^{n^k} x_i^k = S. \tag{4}
  \]

The following notation is used in the above stated problem:

- \( x_i^k \geq 0 \) - cash investment into company \( i \) from sector \( k \), where \( i = 1, 2, \ldots, n^k \);
- \( \beta \in (0, 1) \) - the discount factor used by the bank in order to value payments from future quarters;
- \( T \) is the maximum number of quarters in which at least some companies must repay their loans (maximum loan term);
- \( K \) is the number of different sectors, and \( n^k \) is the number of companies from a sector \( k \) that the bank is considering to include in its loan portfolio;
- \( A_k \) is the maximum share of total investments amount, to be invested into companies from sector \( k \); this parameter reflects the Bank’s sectoral diversification goals.
- \( \gamma_{it}^k \) is the payment of company \( i \) from sector \( k \) in quarter \( t \). The Bank considers values \( \gamma_{it}^k \) as random parameters of its problem (affected, for example, by the market interest rates);
- \( B \) is the expected minimum return of the banking portfolio.

Technically, the formulated problem is a quadratic programming problem, but in practice, its solution raises a number of problems associated with the uncertainty regarding the parameters of the formulated problem. Investors take values as random variables the realizations of which depend not only on an individual component of a specific company’s profitability, but also on a common market-wide profitability and on the average profitability of the companies within the sector \( k \). Consequently, the rate of return can be decomposed as follows (Shukayev et al, 2016)

\[
\gamma_{it}^k = b_i M + c_i^k R_t^M + \varepsilon_{it}^k, \tag{5}
\]

where \( b_i^M \) and \( c_i^k \) determine how sensitive is the profitability of the company \( i \) from the sector \( k \) to changes in the market return, or to changes in its sector-specific return (factor loadings). \( \varepsilon_{it}^k \) is the individual return component of the company \( i \), from the sector \( k \) in period \( t \). Usually coefficients \( b_i^M \) and \( c_i^k \) are calculated using linear regression. By substituting the expression (5) in the formulas (1) and (2) we obtain the problem with “disturbed” parameters, in which the idiosyncratic return component \( \varepsilon_{it}^k \) creates small perturbations in the optimization parameters. As is known in the literature
(Тихонов, 1965; Shukaev, 2010), such optimization problems are typically complicated by the instability of the obtained solutions. The analysis presented in (Зайченко, 2003) proposes the “expansion method” for solving the problem (1-4) with possible “perturbations” of its parameters. This method finds the solution of the original problem (1-4) by generating “a directed descent” to the correct solution starting from a solution of a simpler, expanded optimization problem

$$\min_{\mathbf{x}^T \geq 0} \left[ \sum_{k=1}^{K} \sum_{i=1}^{n^k} \left( \mathbf{x}^T_i \sum_{j=0}^{T} \beta^{k}_{i,j} \mathbf{y}^k \right) \right], \quad (6)$$

$$\sum_{k=1}^{K} \sum_{i=1}^{n^k} \mathbf{x}^k_i = S. \quad (7)$$

The general algorithm for solving the original problem (1-4) with the “perturbed” parameters, starting from the solution of an extended problem (6-7) can be described as follows (Тихонов, 1965; Shukaev, 2010):

1) find a solution of the extended problem;
2) verify consistency of the extended solution with the restrictions (2-3) of the original problem. If the solution is admissible then it is optimal;
3) if the proposed solution is not admissible then determine a descent direction and choose a step size as described in (Shukaev, 2010);
4) transition to a new solution.

This method delivers precise and stable solutions to problems with small perturbations and, in particular, to the problem (1-4) for any given set of its parameter specifications.

When forming an investment portfolio, it is often necessary to assess the sensitivity of the optimal portfolio to parameters of this problem. For example, the bank might be interested to estimate the effects on the efficiency of its investment portfolio of possible adjustments in the parameters A, which determine the diversification strategy of the Bank. In order to achieve this goal, two approaches can be used: the simulation approach and the analytical approach.

2.4 The simulation analysis of the influence of the diversification parameters

The time varying investment parameters can be modeled using the theoretical distributions, or using the parameter distributions obtained on the basis of statistical data patterns. For example, one can estimate and forecast the prudent values of the diversification coefficients $A_k$ based on their historical realizations for a number of comparable banks. The methods for modeling various random factors are discussed in (Ільюхова, 2004).

The general structure of the simulation analysis of the effect of the diversification coefficient $A$ on the efficiency of the investment portfolio should ensure the fulfillment of the following main steps:

Step 1. Solving the problem (1-4).

Step 2. Modeling of the possible changes in the diversification coefficient $A_k$ (Ільюхова, 2004).

Step 3. Determining the range of changes in the diversification coefficient $A_k$ which leads to an improvement in the optimal solution of the problem (1-4).

Based on the proposition 1 in (Shukaev, 2010), in step 2 above, one can use the inverse function method in order to simulate the possible changes of the effective restrictions $A_k$ on the right hand side of the equation (3), by a random continuous quantity $\Delta A_k$ with a known distribution function $f(\Delta A_k) > 0$.

“The realizations of the random variable $\Delta A_k$ can be determined from expression

$$F(\Delta A_k) = \int f(\Delta A_k) ds = U \quad \text{or} \quad \Delta A_k = F^{-1}(U),$$

with its density distribution $f(\Delta A_k)$, where $U$ is a random, uniformly distributed variable in the interval [0,1].”

Alternatively one can model the discrete changes in $\Delta A_k$ as possible realizations occurring with the probabilities $\Delta P_{k,j} \left( j = \overline{1,m} \right)$, specified in the table

$$\Delta A_k = \begin{pmatrix} \Delta A_{k,1} & \Delta A_{k,2} & \ldots & \Delta A_{k,m} \\ p_{1}^A & p_{2}^A & \ldots & p_{m}^A \end{pmatrix},$$

as detailed in the proposition 2 in [19]: “The value $\Delta A_{k,j}$ occurs with probability $p_k$ as long as $U \in \Delta_k$, where $\Delta_k = p_k$.”

The proofs of these propositions are given in (Ільюхова, 2004).

3. Conclusion

The global financial and economic crisis revealed weaknesses in the existing methods and procedures used for analyzing the efficiency of investment activity and generated a renewed interest in the research area devoted to optimal investment strategies. As part of our broader research program, the present paper studies the general principles of bank’s investment activity, using an example of the Development Bank of Kazakhstan. We propose the simulation model structure and the algorithm for analyzing the efficiency of the bank’s investment activities. We discuss the application of the “extension method” for solving the problem of optimal Bank’s portfolio formulation, taking into account instabilities and “perturbations” of the parameters in the model. We also outline the step-by-step algorithm for simulating the influence of the diversification parameters on the efficiency of the investment portfolio.

Our analysis of efficiency of a bank investment activity, and the proposed simulation method are sufficiently universal and relevant not only for implementation of the
Government strategy in this direction, but also for the commercial interests of any bank, including the Development Bank.

References