SYSTEM AND METHOD FOR ANALYZING, MODELING AND EVALUATING THE INVESTMENT PROCESS IN START-UP COMPANIES

M.G. Nosova, *Candidate of Physical and Mathematical Sciences*
Tomsk State University of Control Systems and Radioelectronics
(Russia, Tomsk)

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Abstract. *For investment management, an analytical system and method are available that allow analyzing, planning, modeling and evaluating the investment process within a separate project (start-up) or a company, taking into account the impact of random investment risks and uncertainty. The computer method using mathematical and simulation modeling of the investment process allows, using the input data entered by the user, to calculate financial outflows and inflows for the investment period, determine the optimal volume of investments, predict the number of customers and the company's capital. The user can apply the coefficients of variation to the numerical values used in the calculation phase. This allows you to quickly and easily simulate different scenarios for the development of the company and make effective decisions.*

Keywords: *start-up, investment process, mathematical model, modeling.*

In business, specialists often face the need to assess the company's activities, its capital and the feasibility of economic investment in it. To do this, as a rule, a financial analyst (or a group of analysts) forecasts possible profit and losses from investments, using values about expected sales, production, costs, payroll, tax payments, etc. and calculates the net present value of the investment. The net present value result gives a single monetary indicator that characterizes whether the expected cash received from investments during the investment period exceeds the cash that must be paid during the investment period. This indicator is often used in deciding whether to invest [1]. However, investment decisions are complicated by various factors: the type of investment, the cost of the investment project, the multiplicity of available projects, the limited financial resources available for investment, and the risk associated with the adoption of a decision.

Analyzing the effectiveness of various investment projects, one often has to face the fact that the cash flows (expenses and incomes) considered during their evaluation are forward-looking and predictive. Uncertainty of future results is due to the influence of many economic factors (fluctuations in market conditions, prices, exchange rates, inflation, etc.) that do not depend on the efforts of investors, as well as a sufficient number of non-economic factors (climatic and natural conditions, political relations, etc.), which are not taken into account in the methodology of net present value.

Therefore, the objective of the research is to provide a methodology for financial analysis (and tools based on it) that allows you to analyze, plan, model and evaluate the investment process within a separate project (start-up) or a company, taking into account the impact of random investment risks and uncertainty. This methodology allows calculating the main financial characteristics of the company's activities, such as the calculation of financial outflows and inflows for the investment period, the optimal volume of investments, the number of customers and the company's capital, and models of different development scenarios for a separate project (start-up) or a company, applying variation coefficients to the original numerical values inputted by the user. In addition, financial analysis based on the calculations and estimates obtained allows making effective decisions on the continuation, suspension or termination of investments.

The following detailed description corresponds to an illustration of the general principles of the system and method. However, those skilled in the art will understand that the present system and method can be easily

practiced and that numerous variations or modifications are possible.

As mentioned above the present system and method allows to analyze, plan, model and evaluate the investment process within a separate project (start-up) or a company, taking into account the influence of random investment risks and uncertainty, and also to calculate the main financial indicators of the company's activities. The evaluation process helps the investor to make an effective decision to continue, suspend or terminate the investment. The computer program automates many stages of the process by taking user data (via a keyboard, mouse, touch screen or other user input devices), calculates and displays the result on a monitor or other display device. This allows most users, including those who are relatively unskilled in the use of traditional modeling software, to easily, quickly and accurately model and evaluate different scenarios of the company's development and calculate its main financial characteristics.

An investment project, like any financial operation, generates cash flows. The cash flow of the investment project is the receipt of cash and cash equivalents, as well as payments for the implementation of the project, determined for the entire billing period. The calculation of future cash flows arising from project implementation is one of the most important tasks of economic analysis of investment projects and companies.

The present system and method embody a methodology in which the future cash flows of a project or company are estimated by (1) the expected results (i.e., cash flows), (2) given by the user, to generate a distribution of possible future performance of the company and (3) known probability methods and statistics for modeling and evaluating different scenarios of the company's development [2-3].

More specifically, aspects of the present system and method are embodied in the form of a mathematical model in the form of a queuing system with an unlimited number of serving devices. Depending on the purpose and depth of the investigation, the systems MAP|M|∞, MMP|M|∞ or the classical M|M|∞ with the simplest incoming requests flow and the exponential time of their service on the devices can be chosen as the queuing system [4].

In the course of the study of such a mathematical model, the apparatus of the theory of probability, random processes, queuing theory, and perturbation theory is applied. In the process of research, the method of moments and the modified method of asymptotic analysis are used.

The queuing system can be considered as a mathematical model of the cash flows of a separate project (start-up) or a company. Investments can be considered as a series of future inflows and outflows of cash.

The incoming cash flow from clients is expediently divided into *i* groups (depending on the type of the source of receipt of funds, for example, money from a certain type of provided services), each group is serviced in the system in a certain way. Each of the *i* incoming flows (cash flows to the separate project or company) has an intensity λ_i, i=1..n-1.

In addition, the input of the system receives the *n*-th investment flow with a parameter λ_n that determines the flow of funds from the investments made.

The first type of money goes to the first service unit, the second type to the second service unit, and so on and occupy any of the free devices on which their maintenance is performed for a random time, for example, distributed according to the exponential law with parameters μ_i, i=1..n respectively.

The activities of a particular project or company can be characterized by two random variables: the number of clients involved $k(t)$ and the company's capital $S(t)$ at a particular time *t*. We will assume that the potential market for a separate project (start-up) or a company is considered to be endless. The change in the number of attracted customers (buyers of services and investors) and the values of the project or company's capital occurs in the following cases.

1. The company attracts a new customer for its services or products. We assume that the flow of funds from clients consists of *i* flows with parameters λ_i, i = 1..n-1. The probability that during the time Δt the com-

pany will attract a new customer and, accordingly, the cash is $\lambda_i \Delta t + o(\Delta t)$. Each new customer brings revenues φ_i to the company, which are random variables with distribution functions F_{φ_i} and moments $M\{\varphi_i\} = a_i$, $M\{\varphi_i^2\} = A_i$.

2. We assume that the company receives the *n*-th simplest investment flow with a parameter λ_n. The probability that the company will attract investments over time Δt is $\lambda_n \Delta t + o(\Delta t)$. Each investment brings cash φ_n to the company, which are random variables with distribution functions F_{φ_n} and moments $M\{\varphi_n\} = a_n$, $M\{\varphi_n^2\} = A_n$.

3. For each of the attracted customers k_i of the *i*-th type, the current expenses (wages, taxes, etc.) in the amount ξ_i that is a random variable with the distribution function $F_{\xi_i}(x)$ and moments $M\{\xi_i\} = b_i$, $M\{\xi_i^2\} = B_i$ are paid with intensity $\lambda_{\xi i}$. Payments are made independently of each other and so in time Δt the company will make such payment with probability $k_i \lambda_{\xi_i} \Delta t + o(\Delta t)$.

4. At some point in time, the client leaves the company. We assume that the client's term in the company is a random variable with a distribution function $F_i(x) = 1 - e^{-\mu_i t}$. Each client "leaves" the company with intensity μ_i. Then during the time Δt, clients "leave" the company with probability $k_i \mu_i \Delta t + o(\Delta t)$.

5. For each of the *p* attracted investments, the investment income η is paid with intensity λ_η, which is a random variable with the distribution function $F_\eta(x)$ and moments $M\{\eta\} = b_\eta$, $M\{\eta^2\} = B_\eta$. Payments are made independently of each other and so in time Δt the company will make such payment with probability $p\lambda_\eta \Delta t + o(\Delta t)$.

The simplest (Poisson) flows, MAP, or MMP flows, which quite satisfactorily describe the real flow of money inflows, can act as random incoming flows.

Under the assumptions made in the mathematical model, two random processes are investigated $k(t)$ and $S(t)$, using the methods of queuing theory [5]. A system of differential equations is obtained that determines the probability distribution of the number of clients of the company. The form of the characteristic function of the magnitude of the change in the capital of an individual project or company is found. By the method of moments, the main probabilistic characteristics of the capital of a separate project (start-up) or company were found: mathematical expectation and variance. The modified method of asymptotic analysis determines the type of distribution of the number of events in the incoming and outgoing streams (determining the inflow and outflow of company funds) of the queuing system that occurred in the investigated flows over a certain time (investment period).

In addition, an imitation model of the investment process of the project or company is constructed, provided that the time of receipt of funds and investments in the first case is subject to the uniform distribution law, and in the second case to the stationary Poisson distribution law, and the company's capital is calculated at time *t*, and also the number of financial outflows and inflows for the investment period.

This system and method can be used to make investment decisions and to obtain information about the value of the company at any future time. This is an effective and convenient way of obtaining additional information and processing the information received in the process of making investment decisions.

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СИСТЕМА И МЕТОД ДЛЯ АНАЛИЗА, МОДЕЛИРОВАНИЯ И ОЦЕНКИ ИНВЕСТИЦИОННОГО ПРОЦЕССА В START-UP КОМПАНИЯХ

М.Г. Носова, *канд. физ.-мат. наук*
Томский государственный университет систем управления и радиоэлектроники (Россия, г. Томск)

Аннотация. *Для управления инвестициями предлагается аналитическая система и метод, позволяющие анализировать, планировать, моделировать и оценивать инвестиционный процесс в рамках отдельного проекта (start-up) или компании, с учетом влияния случайных инвестиционных рисков и неопределенности. Компьютерный метод с помощью математического и имитационного моделирования инвестиционного процесса позволяет, используя исходные данные вводимые пользователем, производить расчет финансовых оттоков и притоков за инвестиционный период, определять оптимальный объем инвестиций, прогнозировать число клиентов и капитал компании. Пользователь может применять коэффициенты вариации к числовым значениям, используемым на этапе расчета. Это позволяет быстро и легко моделировать разные сценарии развития компании и принимать эффективные решения.*

Ключевые слова: *start-up, инвестиционный процесс, математическая модель, моделирование.*