

MUHANDISLIK

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ИМЕНИ Г.В. ПЛЕХАНОВА
ТАШКЕНТСКИЙ ФИЛИАЛ



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- 05.01.00 – Axborot texnologiyalari, boshqaruv va kompyuter grafikasi
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05.01.03 – Informatikaning nazariy asoslari
05.01.04 – Hisoblash mashinalari, majmualari va kompyuter tarmoqlarining matematik va dasturiy ta'minoti
05.01.05 – Axborotlarni himoyalash usullari va tizimlari. Axborot xavfsizligi
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05.02.00 – Mashinasozlik va mashinashunoslik
05.02.08 – Yer usti majmualari va uchish apparatlari
05.03.02 – Metrologiya va metrologiya ta'minoti
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05.06.01 – To'qimachilik va yengil sanoat ishlab chiqarishlari materialshunosligi
05.08.03 – Temir yo'l transportini ishlatish
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08.00.16 – Raqamli iqtisodiyot va xalqaro raqamli integratsiya
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Ma'lumot uchun, OAK

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9. Jizzax politexnika instituti



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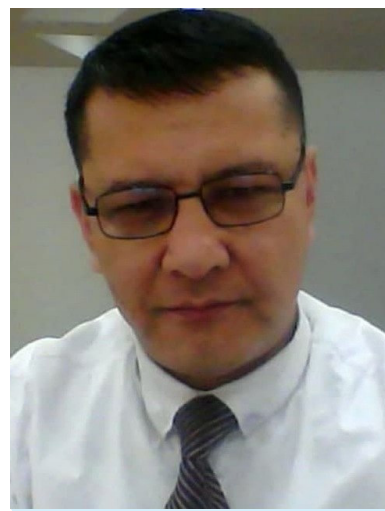
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ENHANCING LIQUIDITY MANAGEMENT EFFICIENCY IN JOINT-STOCK COMPANIES USING THE GEOMETRIC BROWNIAN MOTION (GBM) MODEL



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Abstract. The scientific article studies the effectiveness of using the Geometric Brownian Motion (GBM) model, which is considered one of the modern methods for effective liquidity management in joint-stock business entities. The article empirically analyzes the nature of random fluctuations in cash flows and their volatility based on a probabilistic-statistical approach. In the case of “Qizilqumsement” JSC, logarithmic growth rates and GBM parameters (μ and σ) were estimated based on data for 2017–2024. A cash flow forecast simulation for 2025–2035 was developed using Monte Carlo simulation (1000 scenarios). As a result, it was proven that high volatility and a negative trend in cash flows were observed and that it is necessary to introduce buffer mechanisms to manage liquidity risks.

Keywords: Geometric Brownian Motion (GBM), cash flows, liquidity management, volatility, Monte Carlo simulation, Cash Flow at Risk (CFaR), 3σ risk model, reserve buffers, current financial stability, forecasting, simulation.

Annotatsiya. Ushbu ilmiy maqolada aksiyadorlik jamiyatlarida likvidlikni samarali boshqarishning zamonaviy usullaridan biri hisoblangan Geometrik Braun harakati (GBM) modelidan foydalanish samaradorligi o'rganilgan. Maqolada pul oqimlarining tasodifiy tebranishlari va ularning volatilligi ehtimollik-statistik yondashuv asosida empirik tahlil qilinadi. “Qizilqumsement” AJ misolida 2017–2024-yillar ma'lumotlari asosida logarifmik o'sish sur'atlari va GBM parametrlari (μ va σ) baholangan. Monte-Karlo simulyatsiyasi (1000 ta ssenariy) asosida 2025–2035-yillar uchun pul oqimlari prognozi ishlab chiqilgan. Natijada pul oqimlarida yuqori volatillik va salbiy trend mavjudligi aniqlanib, likvidlik risklarini boshqarish uchun bufer mexanizmlarini joriy etish zarurligi asoslab berilgan.

Kalit so'zlar: Geometrik Braun harakati (GBM), pul oqimlari, likvidlikni boshqarish, volatillik, Monte-Karlo simulyatsiyasi, Cash Flow at Risk (CFaR), 3σ risk modeli, zaxira buferlari, joriy moliyaviy barqarorlik, prognozlash, simulyatsiya.

Аннотация. В данной научной статье исследуется эффективность использования модели геометрического броуновского движения (GBM), рассматриваемой как один из современных методов эффективного управления ликвидностью в акционерных обществах. В статье эмпирически анализируется характер случайных колебаний денежных потоков и их волатильность на основе вероятностно-статистического подхода. На примере АО «Qizilqumsement» на основе данных за 2017–2024 годы были оценены логарифмические темпы роста и параметры GBM (μ и σ). С использованием моделирования Монте-Карло (1000 сценариев) разработан прогноз денежных потоков на 2025–2035 годы. В результате выявлены высокая волатильность и отрицательная динамика денежных потоков, а также обоснована необходимость внедрения буферных механизмов для управления рисками ликвидности.

Ключевые слова: геометрическое броуновское движение (GBM), денежные потоки, управление ликвидностью, волатильность, моделирование Монте-Карло, Cash Flow at Risk (CFaR), модель риска 3σ , резервные буферы, текущая финансовая устойчивость, прогнозирование, моделирование.

INTRODUCTION

In modern corporate finance, effective liquidity management is one of the important factors for the sustainable development of joint-stock companies in their current state. In the context of global economic uncertainties, rapid market volatility, and increased risk factors, the issue of accurate forecasting and management of cash flows is emerging as a pressing issue on the agenda. As is known, traditional deterministic models in many cases do not fully reflect the random and stochastic nature of cash flows. Therefore, models based on probabilistic-statistical approaches, in particular the geometric Brownian motion (GBM) model, are widely used in forecasting. This article also aims to develop the possibilities of using the GBM model to improve the effectiveness of liquidity management in joint-stock companies and the scientific and methodological foundations of its application in practice.

REVIEW OF LITERATURE ON THE SUBJECT

The classical theory of cash management and forecasting was developed in the studies of W. Baumol [1], and the EOQ (inventory) model of optimal cash management [2] was systematized by J. Tobin. M. Miller and D. Orr [3] put forward the theory of liquidity preference and optimal allocation of money demand in their scientific studies. An improved version of the Miller–Orr model based on forecasting was systematized in the scientific works of B. Stone [4]. In the works of such researchers as Frenkel JA and Jovanovic B. [5] the Baumol–Tobin model was developed in a dynamic and stochastic form. Economists such as Salas-Molina F., Rodríguez-Aguilar JA systematized modern and innovative approaches to cash management and forecasting [6]. Also, the first risk and simulation-based models were systematized in the scientific works of P. Jorion [7], who conducted scientific research on the concept of VaR and risk management.

RESEARCH METHODOLOGY

The methodology used was probabilistic statistical analysis, scenario modeling, CFaR and 3σ risk intervals, as well as empirical analysis. The object of the study was to assess the volatility of cash flows, liquidity risks, and the level of financial stability based on the financial statements of the joint-stock company “Qizilqumsement”.

ANALYSIS AND RESULTS

The basic theoretical basis of the Geometric Brownian Motion (GBM) model dates back to several works by mathematicians and physicists. However, the first to use and widely disseminate the GBM model to model the random movement of asset prices in finance was Paul Samuelson, and later Fischer Black, Myron Scholes, and Robert Merton.

Brownian Motion and its financial counterpart, Geometric Brownian Motion (GBM), are widely used to model the periodic fluctuations of cash flows in joint-stock companies. This model is especially useful in accounting for the random nature and variability of financial indicators such as stock prices, earnings, and cash flows.

Brownian motion is a random process that is based on fundamentally stable, centered normally distributed variations. In an idealized form, the Brownian motion model can be expressed as follows:

$$W(t) \sim N(0, t) \quad (1)$$

Here, $W(t)$ is the Brownian motion in the time interval; t is the time horizon, and $N(0,t)$ represents the normal distribution with mean 0 and variance t .

Cash flows for businesses (e.g., cash flow from operating activities) are often represented by the GBM model, and the general structure of the model used in it can be expressed by the following formula:

$$dC_t = \mu C_t dt + \sigma C_t dW_t \quad (2)$$

Where: C_t is the cash flow at time t , μ is the average growth rate of cash flow, σ is the volatility; W_t is the standard Brownian motion, dt is the small change in time, and dW_t is the random noise.

Brownian motion and the GBM model are important theoretical and practical methods for modeling the cash flows of joint-stock companies based on periodic and random fluctuations. This model is useful for evaluating investments, forming a company's risk profile, and making financial decisions.

The GBM model has an analytical solution suitable for real-world situations, which can be expressed as follows:



$$C_t = C_0 * e^{(\mu - \frac{1}{2}\sigma^2)t + \sigma W_t} \quad (3)$$

Based on this analytical solution, it is possible to simulate the forecast indicators of what fluctuations are expected in the future period in the cash flows of a joint-stock company. In particular, this model can be widely used not only for cash flows, but also for cash flows from operating activities; for the forecast of expected income from investment projects; for the simulation of free cash flow (FCF) forecasts, as well as for stress tests in financial stability analyses and long-term forecasting of dividends.

Based on the above theoretical considerations and systematized models, we form forecast simulations of cash and cash equivalents for JSC «Qizilqumsement» in accordance with the GBM model for the medium term. In this case, we form dynamic trends in the enterprise’s cash and cash equivalents for 2017-2024 (Figure 1).

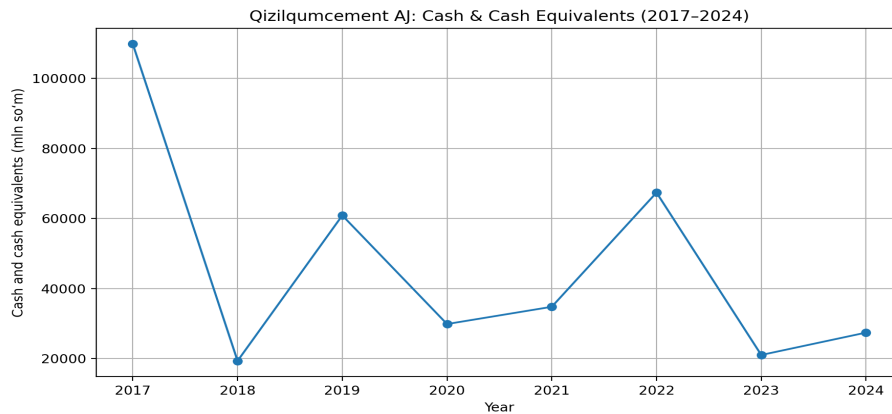


Figure 1. Information on the nominal value of cash and cash equivalents for JSC «Qizilqumsement», million soums

Based on the above statistical data, we perform the following to generate forecast simulations according to the GBM model.

Based on the above dynamic trends, we calculate the logarithmic growth (log-return). The following formula is used to calculate this logarithmic growth:

$$R_t = \ln(C_t / C_{t-1}) \quad (4)$$

The estimated log-growth rates for the period 2018–2024 are mainly observed in the interval (-2;2) and are presented below (Figure 2).

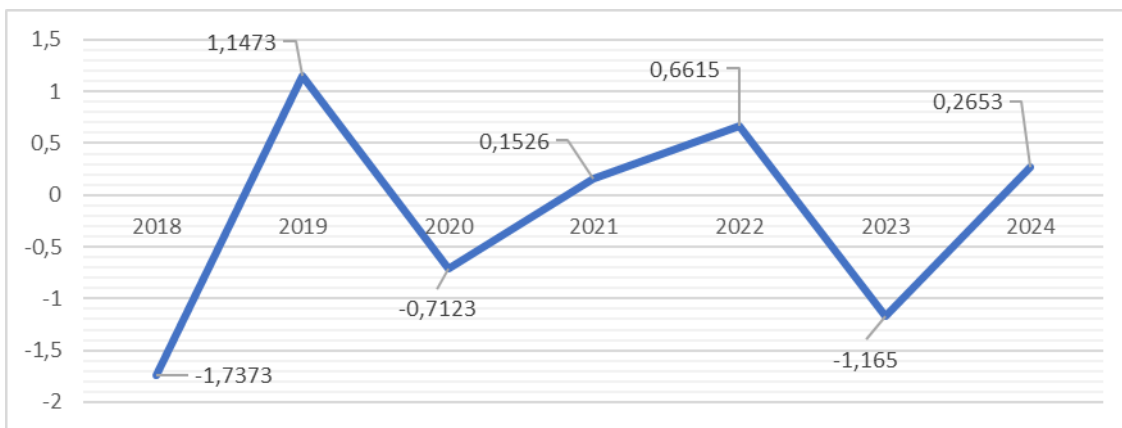


Figure 2. Estimated log-growth for 2018–2024 years

Based on the GBM model, the necessary parameters (μ and σ) for calculating the cash forecast simulation are estimated. In particular, μ is the average log-growth, σ is the standard deviation (volatility) of the log-growth. As a result of the calculations, the average log growth for the nominal value of cash and its equivalents for “Qizilqumsement” JSC based on the dynamic trends of 2018-2024 years was $\mu = -0,1983$ (annual), and the standard deviation was $\sigma = 1,0372$.

The GBM model and the stochastic equation for the simulation are expressed (2) below.

$$dC_t = \mu C_t dt + \sigma C_t dW_t \quad (5)$$

In discrete-time representation, forecast simulation is calculated according to the following formula:

$$C_{t+1} = C_t * e^{(\mu - \frac{1}{2}\sigma^2) + \sigma W_t}, \quad W_t \sim N(0,1) \quad (6)$$

Here, C_{2024} was taken as the starting value of Cash.

Below are the expected value (Mean), Median, 5%-95% range, and standard deviation for each year (Figure 3).

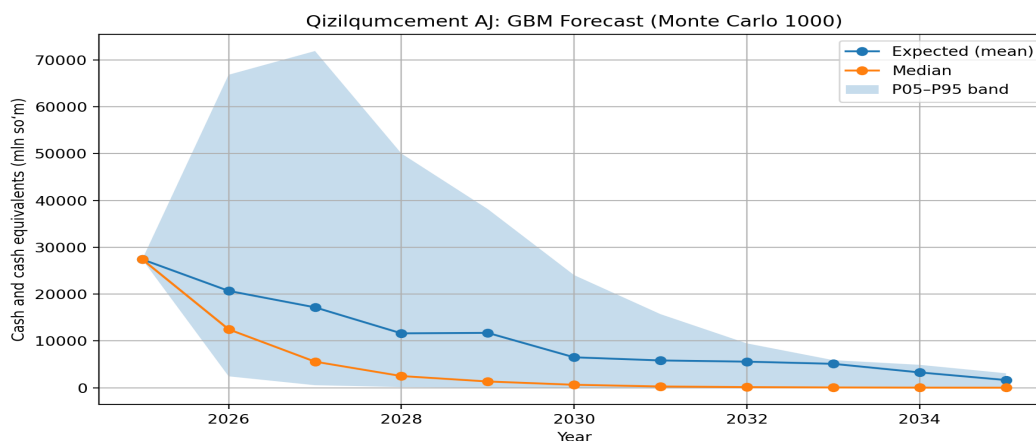


Figure 3. Forecast simulation of the nominal value of cash and cash equivalents for “Qizilqumsement” JSC

Therefore, it can be concluded that due to the sharp fluctuations of money in the 2017–2024 years data, the high σ (volatility) was confirmed. This picture means that the ranges will be wide in the coming period as well. μ is negative ($\mu < 0$), that is, the “average trend” is expressed in the downward direction. Therefore, the median forecast has the characteristic of a rapid decline. The simulation confirmed that starting from 2026, the nominal value of money will be lower than the 2024 level. Based on the above, it can be noted that it is advisable to set a liquidity buffer (minimum L limit) and “upper–lower–target” limits, and place excess funds in short-term risk-free instruments.

For “Qizilqumsement” AJSC (2017–2024 years), GBM parameters (μ , σ) from the Cash and cash equivalents line, a forecast for 2025–2035 years based on 1000 Monte Carlo scenarios, and risk/volatility ranges were prepared in a simple-consistent form.

CONCLUSIONS AND SUGGESTIONS

Based on the results of the study, the following scientific conclusions were formulated:

The dynamics of the funds of “Qizilqumsement” JSC has high volatility, which is reflected in the parameters of the GBM model ($\sigma = 1,0372$).

The negative logarithmic growth rate ($\mu = -0,1983$) indicated a downward trend in cash flows in the coming period.

According to the results of Monte Carlo simulations, it was determined that there is a high probability that starting in 2026, the level of funds will be lower than in 2024.

Fluctuations in cash flows over a wide range increase liquidity risks, and traditional management methods may be ineffective in this case.

Based on the above, the following suggestions can be systematized:

1. Introduction of a liquidity buffer (minimum cash reserve) in enterprises;
2. Continuous risk monitoring through CFaR and 3σ models;
3. Investing excess cash and cash equivalents in short-term risk-free financial instruments;
4. It is necessary to implement strategic financial planning based on the GBM model.

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